MANAGEMENT EDITION

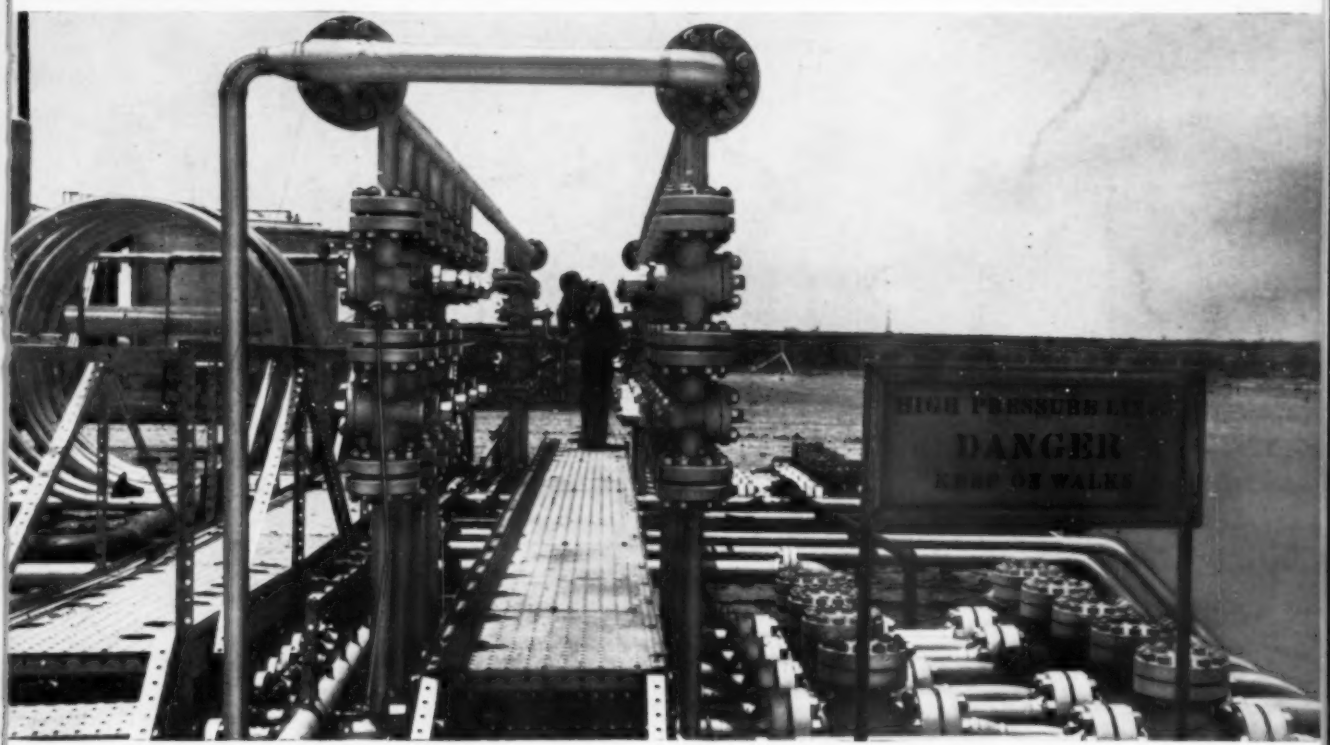
THE Petroleum Engineer

Exploration
Drilling
Producing

Refining
Petrochemical
Gas Processing

Oil . . Gas
Products
Pipelining

What Makes a Man Work?
The Philosophy of Reading
Unrest Among Engineers
Punched Card System for Petroleum Research



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ROCKWELL-Nordstrom VALVES

Lubricant Sealed for Positive Shut-off

40th YEAR *of lubricated plug valve leadership*

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A Magazine of Petroleum Management Engineering

the Petroleum Engineer

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MANAGEMENT EDITION

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REFINING AND PETROCHEMICAL

OIL AND GAS PIPELINING

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Is This Economic Waste?

One of the chief arguments of opponents to the depletion allowance is that it encourages uneconomic drilling for oil and gas. In this ivory-tower reasoning, the petroleum industry hits the bit too often into the earth's subsurface in its search for new resources. Carried to its logical conclusion, the only wells that should be drilled are those where the operator is absolutely certain there will be oil and/or gas. That would indeed be more economic and certainly no depletion allowance would be necessary.

In time the results of this economic type of drilling that needs no depletion allowance would also make uneconomic the manufacture of many automobiles, gas ranges, fuel oil furnaces, diesel engines, and other things that make up our standard of living now.

If you are thinking that imported oil will take care of most of this demand, you'd be right for awhile but the U.S. oil industry, which has developed more than half the petroleum resources of other countries, didn't learn how to drill successfully for oil in Venezuela or in the Middle East. The industry got its experience, its funds, its equipment, and its confidence right here at home doing some pretty uneconomic drilling at times to get them.

One of the most uneconomic phases of drilling that the industry keeps doing is going deeper all the time. These deepest wells average in cost more than $600 thousand each, and some of them cost $2½ to $3 million. It is true that wells below 15,000 ft have a better chance of finding oil and gas, but most of these discoveries are in shallower sands so why spend that extra money to go far below production?

When THE PETROLEUM ENGINEER began its deep well survey 10 years ago there were some 50 wells drilled below 12,000 ft. The cost was high and methods and machinery were not geared for such depths. Suppose the political theorists had persuaded Congress then that depletion allowance should be limited to more economic wells of 10,000 ft or shallower?

It would be difficult for statisticians to determine exactly how much production comes today from below 10,000 ft but it is a substantial share of our total production. It is now economic enough to convince the most skeptical.

The $50 million spent on wells below 15,000 ft that were completed in 1955 and the $100 million planned for 1956 deep drilling must be recovered in the future when experience has made this depth pay off efficiently. Then the industry will be venturing into wells below 25,000 and 30,000 ft in the deep basins and offshore.

That is, it will if the depletion tax allowance remains to buy the industry time to turn uneconomic depths into economic production.

Ernestine Adams

QUO VADIS?

When the U. S. Congress in 1956 passed on the Fulbright-Harris bill to remove natural gas producers from Federal control, it was only repeating what it wrote into the early bill controlling interstate transmission lines. It was clearly stated that the independent producer was not to be under control of the Federal Power Commission.

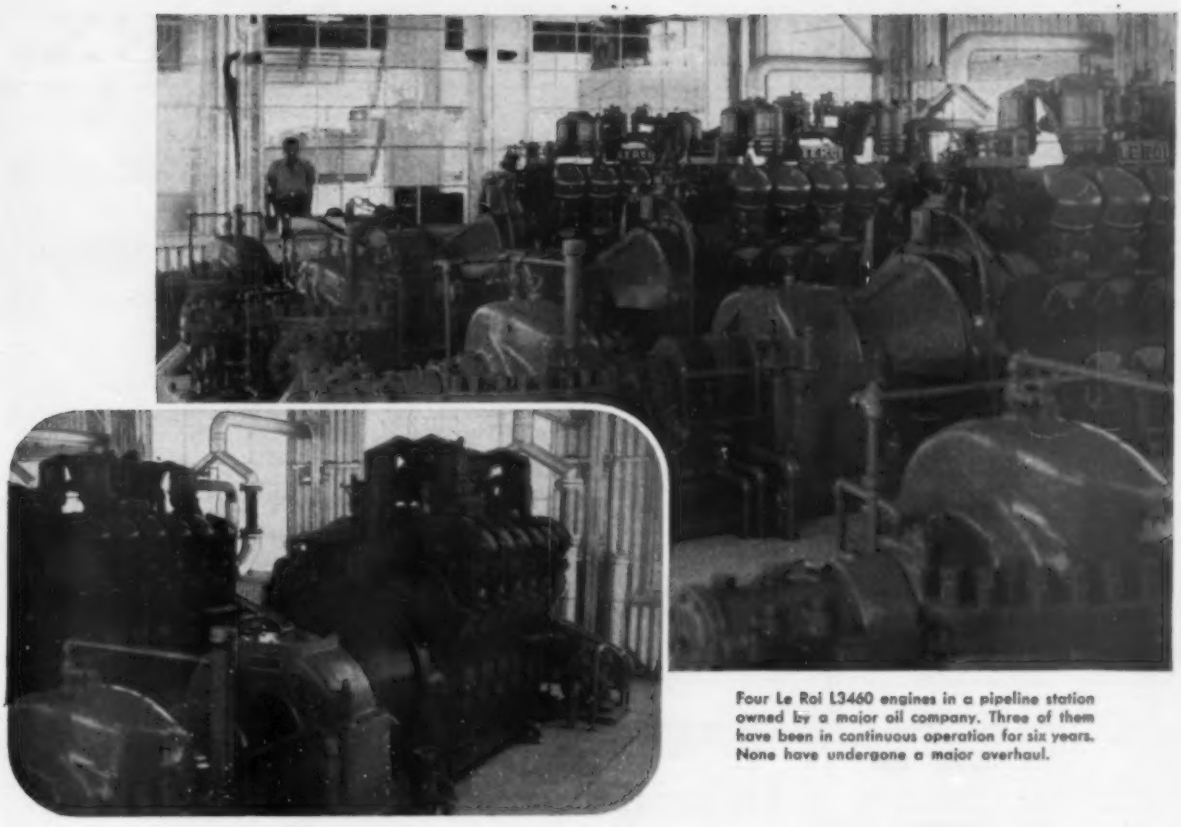
The Supreme Court decision in the Phillips case was greatly puzzling to many people, both in and outside the oil and gas industry.

Quo Vadis? Where are you going? In this case the Congress is going along with the basic principle in our free enterprise system — the principle that only a free market can provide a supply of goods or services at minimum cost.

It is good to know in an age where many leaders turn backward to tribal or communal economics that our own Congress sticks to the belief still new and radical in the history of man — that competition is better than regulation and prices in a free market serve the consumer better than prices set by any government.

Passage of the Fulbright-Harris bill gives a new lift to all those who believe in a republican form of government and in an economy initiated by individual enterprise.

Quo vadis? In the right direction.



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Long engine life—Perhaps the best proof of this statement is found in the trouble-free performance experienced by users in installations like the one shown above. Basically the L3460 and L4000 are compact, high-output engines designed with short stroke to give you greater horsepower and speed, without compromising engine life. And that's exactly what they do for you.

More comfortable operating conditions—Water-cooled exhaust manifold cuts down engine heat in operating areas, yet provides fast engine warm-up. The smooth, clean lines of these engines prevent dirt from collecting—that's why they are so easy to keep clean.

Compact V-12 design packs a lot of horsepower in a small space—to give you more horsepower per dollar. This, plus vibrationless performance, reduces foundation costs, simplifies installation.

We think that if you see an L3460 or L4000 in operation you'll agree that they provide the answer to low-cost pumping power. Have your supply house or Le Roi distributor show you one at work. Bulletins are available upon request—just write us.

P-140

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TRACTAIR

STATIONARY AIR COMPRESSORS

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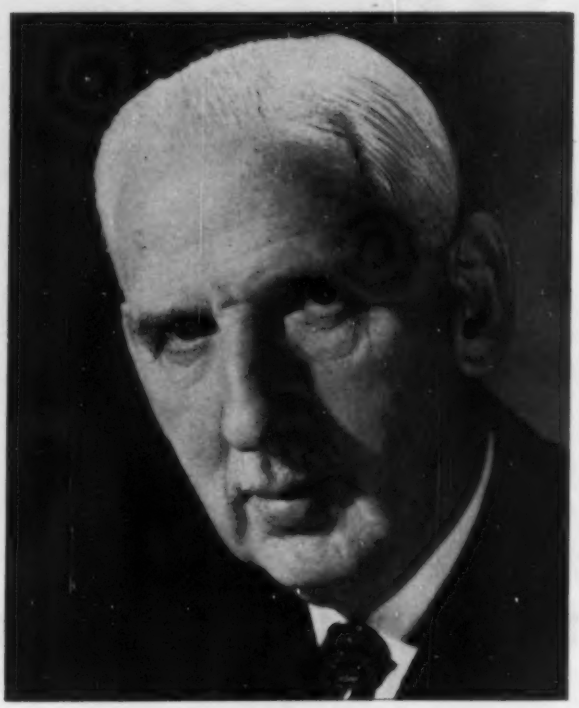

LORD STRATHALMOND
Chairman
The British Petroleum Company, Ltd.

THE Persian Government had cancelled the oil concession held by the largest British oil company—Anglo-Persian Company, as it was named then. The 44-year-old deputy-chairman, William Fraser, hastened to the Middle East to straighten the matter out, for the concession had been granted in 1901 for 60 years.

That was in 1932. The Scotsman carried on successful negotiations with the government, drawing up one of the most generous contracts at that time and extending the period it covered to 1993.

When the 1933 contract was repudiated in 1951 by an oil nationalization law, the same William Fraser, now the chairman of Anglo-Iranian, (the name had been changed in 1935) led his company's efforts to settle the dispute. He played an important part in the formation of the consortium, which in November 1954 set the Iranian oil industry into operation once more.

More significant in reviewing the biography of Sir William is that the company which he directed wasted little time crying over spilt oil in Iran. It forged ahead to regain its high position in world oil affairs by seeking oil reserves in other countries. The loss of the Iranian property inspired new aggressive policies. Anglo-Iranian — now The British Petroleum Company, Ltd. — began a large program of development in many concessions that Sir William had contracted earlier.

The great man of the British oil industry was born in Glasgow, Scotland, one of eight children of the founder and managing director of Pumpherston Oil Company, a shale oil concern. Educated at Glasgow Academy and the Royal Technical College, Glasgow, he went to work for his father's company when he was 21. He remembers that he had to start at 6:30 in the morning on this first job and earned the sum of £1 a week. He must have been doing better in 1913. He got married and became a director of the company. When his father died in 1915, he took on the responsibility of top management at the age of 27 and in 1918 a further duty was laid on his young shoulders — the chairmanship of the committee that dealt with petroleum products for the Allies in World War I.

The first World War left the Scottish shale oil industry in a shambles and William Fraser persuaded the industry to organize a joint marketing division to cut costs. When Anglo-Persian wanted to extend its markets to Scotland, the young man suggested that the shale oil organization be used. Seven shale oil companies were merged under the name of Scottish Oils, Ltd., with Fraser as managing director.

He was asked to join the board of Anglo-Persian in 1923 and not long after made his first trip to Persia. His work so impressed the board that he was offered the deputy-chairmanship, which he did not accept until 1928 because of his reluctance to leave Glasgow.

The new deputy-chairman played a leading role in development of Iraq Petroleum Company, which holds many Middle East concessions, and he negotiated the agreement that formed the Kuwait Oil Company, which holds the now fabulous Kuwait concession.

In 1939 he was knighted for his public services and in 1941 Sir William became chairman of the Anglo-Iranian Oil Company, Ltd.

Not only has Sir William's vast knowledge of the industry and ability been important in his active leadership of British Petroleum, but his humor, his kindliness and understanding have endeared him to his associates and the employees of his company.

His country has found Sir William a patriotic and untiring worker. As in World War I, he served the war office before and during the Second World War on the Petroleum Board. In 1951-52 he was Chairman of the Oil Supply Advisory Committee. A Barony was conferred on him in the 1955 New Year Honors, and he assumed the title of Lord Strathalmond, of Pumpherston in the County of Midlothian.

On March 31, 1956, after 33 years of service to his company, Lord Strathalmond will retire. He has a delightful family to help him enjoy his new leisure. Besides Lady Strathalmond, there are a son and daughter, both married, and five grandchildren. Everyone expects he will also devote more time to his favorite recreations — golf and shooting.

Ed - This is something for every oilman to think about! G.H.

PUBLISHER'S PAGE

Whose Job Is It?

Whose job is it to see that the oil business has a better understanding at the hands of the public? Is it just the job of the American Petroleum Institute and its committees? Is it just the job of the company executive who may be a heavy stockholder—or who may not be but who has an interest in keeping a good job?

No, the responsibility goes far deeper than that. It goes to *every* individual who works in the oil business whether he works out in the oil fields, in a refinery, on a pipe line or works at a pump in a filling station.

If he intends to stay in the oil business then he had better do everything he can to help the oil industry get and maintain a good name at the hands of the public. His job is likely to be just about as stable as is the reputation of his industry

How can you or anyone employed in the oil industry help it to secure and maintain a good name?

The answer to that is easy:

• So conduct yourself in all of your operations as an oil man in contact with the public so that the public will feel "that's a good oil company to do business with."

• If you hear somebody making a statement about the oil industry which your own information tells you is untrue, correct it in a friendly manner.

It is just as simple as that. If the several million employes of the oil industry in the U. S. will do just these two things, the results will be far greater than could be expected from a multi-million dollar advertising campaign.

And just as an editorial writer in one of our publications said last month, "this is not a job for just a week in the year —it is an every-day job, 365 (leap year 366) days in the year."

Ray L. Dudley

Current Outlook Section • 43

This editorial, of vital importance to all oil men and women, appeared in the January, 1956 issue of WORLD OIL and is presented for your information by the

AMERICAN PETROLEUM INSTITUTE
50 West 50th Street, New York 20, New York

Letters From

All that is necessary for the triumph of evil is that good men do nothing...

— EDMUND BURKE

What Do We Do Now?

YOU'VE heard enough to last you, no doubt, about the President's veto of the Fulbright-Harris bill. It seems downright impossible but it happened, so let's go on from there.

What can be done now?

From the scores of Washington statements everybody seems to have pulled his head into his shell. If there is a neck stuck out we can't find it.

Republican Congressmen say the Democrats are in control so they can't initiate a natural gas bill. Democrats say the calendar is too crowded and what can Democrats do in the face of a veto against a bill by a GOP President who says he's for it.

A spokesman for the President says that Eisenhower isn't about to initiate any natural gas bill so you can blow away that pipe dream.

Are we going to sit around and live with this Supreme Court directive that Congress has three times rejected?

We agree with the President that it discourages individual initiative and incentive to explore for and develop new sources of supply.

We agree with his statement that in the long run this will limit supplies of gas — which is contrary to the national interest.

We agree that it is contrary also to the interest of consumers.

We do not agree with some of the President's political advisers that the veto will bring in votes. Only Secretary McKay of the Cabinet is reported to have stood by the bill. It is doubtful that a $2500 campaign contribution offer, turned down by the Senator to whom it was offered and said to have influenced him against the bill, could have been the sole reason for the veto. It is perfectly legal to contribute to a friendly senator's campaign fund.

Senator Paul Douglas' campaign for instance, got $35,000 in contributions from labor unions last time he ran and it wasn't because he voted against labor.

A Senator's pay for the six-year term totals $135,000. *U. S. News and World Report* estimates the average campaign costs $200,000. The only way to pay for it is by contributions.

BUT all this doesn't tell us what to do.

We could, of course, shut up and take it.

Gas can be sold within the state it is produced without federal controls. Fuel oil can be developed — if not here then in foreign countries. It and LPG products can be substituted for gas energy. Gas can be converted into electrical energy and sold across state lines without federal control. (All this could change, of course, if federal control of gas is allowed to stand.)

But when the regulation is wrong and dangerous as the present natural gas law with its present interpretation, it is not enough to try to live with it.

Our industry knows better than most the evil effects of the present law. It is up to us to throw off discouragement and try for the third time to educate the public and bring logic to weigh against the rash statements of some opponents. We cannot quit until the problem is resolved against federal controls in a competitive industry and in favor of "individual initiative and incentive."

Overall the industry did a good job and did it in good faith. There should be better understanding of what FPC control means to natural gas production both in political circles and in consumer areas. Remember, Congress approved the natural gas bill and the President said it was needed.

That is the most support we ever had for the decontrol bill. Let's gather our forces for the third battle. The war isn't lost.

Outside Their Fold

ANOTHER writer places the petroleum industry at the top of the "power" list. Richard H. Rovere states flatly in his "Letter From Washington" (*New Yorker*, February 25, Page 122): "For many years now it has been plain to everyone here that the oil industry wields the most spectacular political power in the country."

The New Yorker article says Senator Hennings, of Missouri, expressed the view that oil money is the greatest single corrupting force in American politics today.

These are harsh words but they follow the same line as *The New Republic* series (*The Petroleum Engineer*, January 1956, Page A-4) on "Oil and Politics."

The oil industry is definitely not popular with the intellectuals of the "liberal" press. It's a sin to make a profit and it's a sin to influence people. Only government controls and then government ownership will satisfy our critics.

Yes, we could use more engineers and we need more engineers. That must make a shortage.

A Couple of Answers

ONE of the oil publications asks a couple of questions: "Are engineers short or do they fall short?"

If there isn't a shortage of engineers, practically every company is off base; not only in the petroleum industry but in most large businesses and industries.

Competition for graduate engineers has advanced starting salaries to the point where it is one of the reasons for unrest among older employees (See Page E-6).

The reason given for this drive for engineers is that industry and business and all levels of government need more engineers and there are too few of them. We are wasting a lot of effort and money and recruiting talent if there is no shortage.

Morris T. Carpenter, Standard Oil of Indiana official

the Editor

and president of Scientific Manpower Commission, said last year that the shortage of engineers has reached a point where it is a threat to national security.

Dr. Alan T. Waterman, director of National Science Foundation, believes there is a dangerous shortage of engineers and scientists in a world divided and striving for political and economic power.

In the petroleum industry, a large number of companies are doing something about it. Many have given scholarships and endowed universities. At least one company has set up a high school teacher-improvement project. There has even been some work done in interesting grade school pupils in math and science. Half a century ago one in every 5 high school students studied physics; now the figure is one in 22.

DO engineers fall short? It would be hard to imagine our industry operating without engineers. Even in the early days there was a hard core of engineers who adapted their knowledge and experience to the demands of this new oil industry. They were in the U. S. Bureau of Mines and in universities and with a few companies. There were also many practical engineers who learned by experience and common sense. They pointed the way to conservation and better efficiency and economics.

Three years ago *The Petroleum Engineer* did a survey of industry companies — integrated, producing refining, pipe line, etc. — on the position of engineers.

Without exception, the replies stated that engineers were assuming greater responsibility and were filling more top management jobs in their companies. Almost all added that company policy included hiring and training young engineers for general or specialist work and for future executive replacements. Over 30 per cent of the personnel now in management are engineers.

As ours and other industries become more complex and more technical the disciplined mind of the trained engineer grows more important. Most of us will agree that the major progress of our industry can be credited to engineering.

Structures are harder to find so who finds the means of pinpointing them? The engineer—with his new methods of pattern shooting and magnetic tape recording.

Who is responsible for a drilling rate now increased to twice as fast as it was 10 years ago? The engineer.

Where are producible reserves doubled? In reservoirs where engineering techniques are applied.

Who invented the new processes that make gasoline 50 per cent more efficient and gets 50 per cent more gasoline out of a barrel of oil than 25 or 30 years ago? The engineer.

Who revolutionized the big expensive pipe line pump stations into the compact, automatic or semi-automatic station of today? The engineer.

Not every person can keep a feet-on-the-ground and head-in-the-clouds attitude that makes the ideal engineer but there are plenty of them to make progress a steady product in this industry of ours.

Net Income 15% Higher in '55

GROSS income for oil companies was 11 per cent higher in 1955 than in 1954, according to preliminary figures for about one-half the petroleum industry.

As we pointed out in the December issue of *The Petroleum Engineer* (Page E-22) this increase is expected to be lower than the overall average for business and certainly way below such industries as automobiles and steel.

Net income showed 15 per cent gain over 1954. The percentage increase is due largely to capital investment in new plants and facilities, which is beginning to pay off. It will be interesting to learn what the earnings ratio is.

Financial Reports of 1955
(Most figures are estimates)

	Gross Income		Per cent of	Net Income		Per cent of
	1955	1954	1954	1955	1954	1954
Anderson-Prichard	61,300	54,865	112	4,934	3,254	152
Ashland O & R[3]	245,881	227,948	108	10,106	6,628	152
Atlantic Refining	513,035	489,747	105	39,464	41,351	95
Bishop Oil	2,363	1,864	127	534	309	173
Continental Oil	528,944	500,125	106	46,300	41,700	111
Cosden Petroleum[4]	42,343	36,529	116	3,560	2,570	139
Hancock Oil[4]	25,046	19,706	127	3,331	3,132	106
Humble O. & R.	—	—	—	175,000	146,303	120
Husky Oil	23,688	13,741	172	717[1]	1,004	71
Kerr McGee[4]	42,328	16,412	258	2,221	411	540
Maracaibo Oil	1,961	1,924	102	380	386	98
Midwest Oil	14,443	—	—	5,993	—	—
Ohio Oil Co.	—	—	—	41,255	38,224	108
Phillips Pet.	900,000	796,000	113	95,000	76,000	125
Plymouth Oil	98,265	91,753	107	6,888	6,759	102
Pure Oil	490,385	391,804	125	35,164	31,163	113
Shamrock	43,181	38,175	113	7,756	7,408	105
Shell Oil	—	—	—	125,500	121,127	104
Signal	58,913	53,918	109	9,640	9,313	104
Sinclair Oil	—	—	—	80,000	74,623	108
Socony Mobil	—	—	—	200,000	184,000	109
Standard Calif.	1,275,000	1,228,000	104	220,000	211,872	104
Standard Indiana	1,813,954	1,677,000	108	157,118[8]	117,160	134
Standard N. J.	6,560,000	5,805,700	113	717,000	585,000	123
Standard Ohio	371,510	324,517	114	23,008	18,527	124
Sun Oil	663,748	661,377	100	48,307	40,344	120
Sunray Mid-Con.[6]	289,387	125,239	238	39,400	36,600	108
Superior Oil[7]	80,518	77,421	104	3,595	10,360	33
Texas Gulf Prod.	16,077	13,327	121	6,320	5,246	120
Texas Pacific C. & O.	23,270	21,270	106	7,949	7,856	101
Toklan Oil	1,311	1,150	114	217	279	78
TXL Oil Corp.[2]	7,135	—	—	2,991	—	—
Union of Calif.	365,000	352,000	104	—	—	
Warren	62,285	56,521	110	5,484	5,204	105
White Eagle	13,365	9,106	147	258	177	146
Wilcox Oil	8,258	9,697	85	982	648	152

[1]Husky's quarterly report ending Sept. 30, 1955 (its annual report ends June 30) had net earnings of $477,914, which is 65% above the same period a year earlier.
[2]First year on N. Y. Exchange.
[3]For fiscal year ending Sept. 30, 1955. Report for first quarter (to Dec. 31, 1955) sales were up 18% and net up 68%.
[4]for 6 mo ending Dec. 31, 1955.
[5]For 9 mo ending Jan. 31, 1956.
[6]1955 includes full year's operations of all present components of company.
[7]For fiscal year ending August 31, 1955. Superior's quarterly report ending November 30 showed gross up 13% and net income up 2%.
[8]Including a non-recurring net profit of $9,235,000.

HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Effects of the passage of the Harris-Fulbright are hard to evaluate. Doubtless the natural gas industry, which suffered from the doldrums in 1955, will drive ahead in the future. Exact Senate voting on the bill, 53 for and 38 against, was a surprise in itself and broke all party lines. The bill was an approval of the same legislation narrowly passed by the House last year. Chief effect of the bill is to exempt independent producers from direct FPC regulation, but also provided indirect control by requiring the commission not to allow gas pipe lines to charge off as an operating cost more than the "reasonable market price" of the gas they buy.

★ ★ ★

President Eisenhower has been asked to back user taxes to finance the federal highway program. The bond program fostered by Eisenhower last year has given way to pay-as-you-go thinking (particularly by the Democrats) in the form of one-cent increases on gasoline and diesel fuel taxes, possible 2 per cent tax increases on the purchase price of trucks, buses and trailers, and higher levies on all tires and tubes. Additional user tax possibilities are on auto parts and accessories and lubricating oils.

★ ★ ★

Shell Oil is currently running a series of quiz-type advertisements designed to "sell" safe driving in 220 daily newspaper throughout the U. S. The full-page ads, which encourage readers to rate themselves as drivers, are noticed by some 74 per cent of the readers — showing an exceptionally high reader interest. The ads have been endorsed by governors, used in high school driver-training classes, and civic safety programs have been developed around them.

★ ★ ★

"Fiercest manhunt in history" is being waged by industry for executive talent, says James Pipkin, a vice president of The Texas Company. Vacancies in management-level jobs are at an all time high, and will remain so in the foreseeable future, and may be blamed on the continuing growth and increasing complexity of the U. S. industrial economy. The process whereby the rank-and-file worker is being given a job that is physically easier, better-paid and more productive with less effort, in turn makes managerial jobs more difficult and has made the jobs of engineers and other technical personnel more demanding, Pipkin asserts.

★ ★ ★

Capital outlay for the U. S. oil industry in 1956 is due to set another all-time record. Most companies are listing capital expenditures much higher that last year. Total outlays for Conoco call for $700,000,000; Jersey Standard, $1.3 billion; Socony Mobil, $419,000,000; Gulf, more than $280,000,000, and Cities Service, $135,000,000.

★ ★ ★

Federal gasoline tax exemption for farmers has been approved by the House Ways and Means Committee and the resulting bill is now in Congress. The action, recommended by President Eisenhower, restricts the exemption to gasoline and diesel fuel for off-the-highway use; lubricants were not included. It is in conflict to past government policy and is the first direct linkage between the federal tax and the highway program, and may prove the way for exemption attempts on the part of airlines.

★ ★ ★

Major oil companies have boosted wages of most employees about 6 per cent with a minimum of about 15 cents per hour. Average increases per employee is about $25 per month; most of the raises became effective February 1. Carter Oil, Gulf, Esso Standard, Socony Mobil, Humble, Continental Oil, Magnolia, Sunray Mid-Continent, Texas, Ethyl, and Phillips are just a few of companies announcing the increases.

★ ★ ★

Tankwagon gasoline prices in Texas have been hiked by several of the major companies. Continental Oil, which initiated the increase, was quickly followed by similar announcements by Humble and Gulf. All posted ½-cent higher levies on both regular and premium grades. The increase has been passed on the retailer in many parts of the state. Companies cite the increased prices have been due to costs brought about by improvements in the quality of gasoline. It is the first Texas increase in about a year.

Top-ranking government mining experts have planned the course to be followed this year in developing the Rifle, Colorado, oil shale mining project. Aided by a $1,000,000 appropriation from Congress, Bureau of Mines personnel has begun boring entrances into the oil shale formation and is renewing studies which were halted more than a year ago. The group feels confident that safer and cheaper methods of mining the oil shale will be found.

★ ★ ★

Pennsylvania grade crude oil has received its fifth price hike in 12 months. Demand for the lubricant-quality oil pushed prices in some districts to $4 per barrel, as posted by South Penn Oil Company. On the West Coast, Standard Oil of California increased prices five cents a barrel on its heavy gravity crude. There is short supply and increased demand for the crude of 14.9 gravity and heavier.

★ ★ ★

"Be prepared to defend the 27½ per cent depletion rate" says Treasury Secretary Humphrey. The official, unlike many past Treasury Department heads, endorses the principle of depletion allowance incentive granted oil and gas interests. Humphrey has stated that "Proper depletion is a very proper deduction and a very desirable one from the whole point of our economy."

★ ★ ★

AIME has given its oil industry members full status by a general name change. It will be known as the American Institute of Mining, Metallurgical, and Petroleum Engineers. Three branches have been created to serve each phase of the 24,000 member organization. The petroleum branch has about 7500 members.

★ ★ ★

Prominent oil men have been called to Texas to aid the State Railroad Commission in setting a pattern for 1956 crude oil production. The Texas oil panel has asked the executives to furnish testimony on desirable stock levels, import intentions and estimated petroleum demand. Letters have been distributed to the heads of all companies who purchase Texas oil, requesting personal appearances at the commission's March 16 proration hearing.

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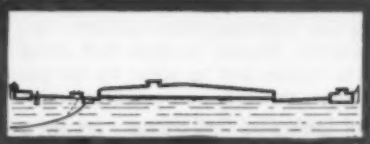

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Defeat of the Harris-Fulbright gas bill is expected to mark the beginning of a long and serious investigation into nearly every phase of the oil and gas industry. Likely Washington actions this year would aim at (1) divorcement between the refining and marketing segments of integrated companies; (2) further elimination of oilmen in government offices; (3) downward revision of the tax depletion allowance; (4) thorough Interstate Oil Compact investigation; (5) an accounting of oil industry lobbying, and (6) antitrust proceedings into gasoline price war practice.

★ ★ ★

Record employment in non-farm jobs was set in December, 1955, hitting a total of 51,200,000. Total employment for the same month was estimated at 64,200,000, about 2,500,000 higher than ever recorded at that time of the year, the Federal Commerce and Labor departments reported.

★ ★ ★

Atomic Energy Commission has approved another nuclear power project near Rowe, Massachusetts. Contract negotiations call for a 134,00-kw plant proposed by 12 private New England utility companies. AEC also has four other atomic power plants under consideration, probably to be located in Illinois, Nebraska and New York.

★ ★ ★

Crude oil severance tax in Mississippi will be doubled if the state legislature is successful in pushing through a new 42-member sponsored bill. The tax, to be increased from 6.81 to 12 per cent, is expected to force the oil industry to build refineries in the state. There are only two small independent refineries in the state now.

★ ★ ★

Supersonic airplane fuel capacity must be increased by refiners, warns Brig. General Will White, former head of the Pentagon's Petroleum Logistics Division and a former official of Jersey Standard. JP-5 fuel, used in jet planes and in some guided missiles, is the subject of extensive lab research in attaining a better high temperature stability.

★ ★ ★

Trans-Canada Pipelines, Ltd., has received a third extension of time to complete financing and commence construction of a line that will bring Canadian gas into the U. S. Midwest. The extension to November 1, 1956, was granted by the Alberta Conservation Board awaiting outcome of FPC hearings now in progress. These hearings, in Washington, concern the natural gas export and import "trade" between the two countries.

★ ★ ★

Foreign Petroleum Supply Committee has been ordered to make major changes in its organization in order to bring its operations under closer government supervision. Attorney General Brownell, who required the changes, has directed that the committee chairman be a fulltime salaried government employee and that government people will head subcommittees; appointments to be made by the defense production administrator. In explaining the change Brownell says the arrangement is designed to keep each company from learning production figures of competitors.

★ ★ ★

Gas will replace oil as the nation's No. 1 heating fuel before the end of the year, says Harold Massey, of the Gas Appliance Manufacturers Association. Massey predicts that about $1¼ billion will be spent by the gas industry this year on new construction and expanding facilities.

★ ★ ★

Coal-burning gas turbine loco-motive, nearing perfection, is expected to be a boon to the fast-slipping coal industry. A stationary model of the turbine is expected to be in operation this year and an actual locomotive built next year. Coal producers and nine railroads have put $4,500,000 into the project. Coal provided railroads with 23 per cent of their fuel energy in 1943 but in 1955 only 1 per cent, due to the vast dieselization program.

★ ★ ★

Government's fast tax write-off program has done little to increase the concentration in the oil industry since 1950, the Justice Department reports. A recent federal study indicates that this tax amortization program has been inclined to favor smaller concerns in the industry. The 20 firms and their subsidiaries which run 80 per cent of the crude through refineries were granted only 73 per cent of the amortization certificates in the past 5 years, thus favoring the small companies by 7 per cent.

Navy will handle all military oil operations, Defense Secretary Wilson has announced. The Navy already had statutory jurisdiction over the Navy Petroleum Reserves and administrative control over the Armed Services Petroleum Purchasing Agency. The order is in line with the Defense Department's new "single manager" policy. Earlier reports hinted that the Air Force, who surpasses the Navy in oil consumption, might obtain control.

★ ★ ★

Law supplying natural gas to farmers for irrigation purposes continues to draw the ire of Phillips Petroleum Company. A group of Cotton County, Oklahoma, farmers have asked the State Corporation Commission to set a price on the gas on which they receive top priority according to the 1955 law. The firm claims this amounts to confiscation of property.

★ ★ ★

Gross national product in 1955 was $387 billions, says one Federal Reserve economist; up 85 per cent since 1946. Figuring a 24,000,000 population gain, however, the average person is getting only 15 per cent more goods and services. The individual's share of the gross national product has climbed from $1774 to $2039 in 10 years.

★ ★ ★

Oil, Chemical & Atomic Work-ers Union has asked Senator Joseph O'Mahoney to broaden his investigation into oil company employee investment rules. The union claims some companies extend restriction to include not only other oil investments but to uranium or thorium stock and mineral rights.

★ ★ ★

Continental Oil Company is continuing its expansion in all directions. It is now more firmly entrenched in the petrochemical business with its purchase of Sherwood Refining Company, a large producer of natural sulfonates and white oils. Conoco has also purchased 92 oil wells in two prolific West Texas pools from the Montal Corporation. Montal had purchased these properties from General American Oil Company last month for an estimated $31,000,000. Expanding internal operations of the company have necessitated creation of a new CATC marine region, with the function of guiding joint-company offshore activities. Expansion-split of the southwestern and southern production regions was announced a few months ago.

1-YARD HOE digs 22½ feet deep

You've come to expect *extra work capacity* in Koehring machines — and you get just that in the new 405, heavy-duty leader in the 1-yard class. On hoe applications, it digs 43 inches wide over side-cutters — 22½ feet deep. Long reach puts spoil bank well beyond edge of cut — and gives 12½-foot clearance height (at beginning of dump) for truck loading. Cutting angle is adjustable to suit digging conditions. Equalizer at dipper assures even pull on each cable.

For all its powerful, fast action, this heavy-duty 405 is an operator's dream! Big power clutch requires only 1/10th the lever pull of a comparative-size manual clutch — yet retains accurate "feel" of load. Automatic traction brakes also simplify operation — are engaged at all times, except when tractive power is applied. They lock and hold the 405 when working or parked. Maintenance is simplified, too. There are only 2 main shafts in the 405's upper machinery. Each assembly is a completely independent unit with fully-enclosed gears, and splined shafts rotating on antifriction bearings.

Those are some of the reasons why you get more work done with every 405 attachment. It readily converts to 1-yard shovel, handles 1 to 1½-yard clamshell or dragline buckets on a wide work radius — has 20-ton lift capacity as a crawler-mounted crane. Your Koehring distributor has more information on this *extra-capacity* 405 that will interest you. Better call him soon — or write us for literature.

mail to:

KOEHRING Co., 3026 W. Concordia, Milwaukee 16, Wis.

Send us ☐ spec. sheets ☐ bulletin on Koehring 405

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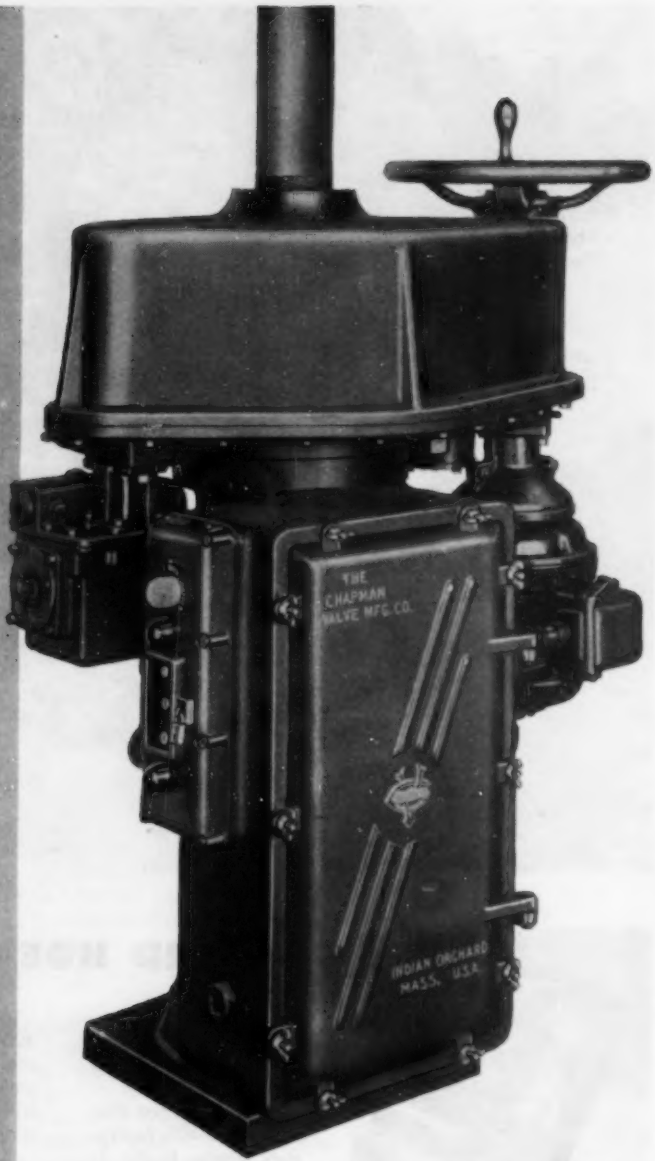
Floorstand Motor Unit . . . control panel, motor, limit switch and push button station.



Simple, durable mechanism of Chapman's Motor Unit. Handwheel remains stationary during motor operation.

IN CHAPMAN MOTOR UNITS

Chapman's simple and rugged Motor Unit gives accurate, trouble-free control of large valves and sluice gates. It has approximately *half as many parts* as any other unit. Its simplified design, low speed motors and low-ratio, stubtooth gears combine to give positive operation without drift, in *any* position and under all conditions.

Installation is fast and simple. The floorstand unit comes completely wired, ready to connect to leads. Limit switch has micrometer adjustment for exact pre-setting for seating tightness. Motor Units operate smoothly under the most adverse conditions. All units are weather-proof and steam-tight. Write today for *new* Catalog 51.

The Chapman Valve Manufacturing Co.

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Meetings

March 12-16—**National Association of Corrosion Engineers,** annual, Statler Hotel, New York, New York.

March 19-21—**Mid-West Gas Association,** Hotel Fontenelle, Omaha, Nebraska.

March 19-20-21—**Western Petroleum Refiners Association,** annual, Plaza Hotel, San Antonio, Texas.

March 21-23—**American Petroleum Institute,** Division of Production, Southwestern district, Texas Hotel, Fort Worth, Texas.

March 21-23—**American Power Conference,** annual, sponsored by Illinois Institute of Technology, Hotel Sherman, Chicago, Illinois.

March 22-23—**New England Gas Association,** annual meeting, Statler Hotel, Boston, Massachusetts.

March 24—**North Texas Oil and Gas Association,** annual, Wichita Falls, Texas.

March 29-30—**American Institute of Mining and Metallurgical Engineers,** Petroleum Conference on Economics and Valuation, Statler-Hilton Hotel, Dallas, Texas.

April 2-4—**American Institute of Electrical Engineers,** Southwest district No. 7, Dallas, Texas.

April 3-5—**Annual Corrosion Control Short Course,** University of Oklahoma Extension Study Center, Norman, Oklahoma.

April 4-6—**American Gas Association,** General Management Section, spring conference, Conrad Hilton Hotel, Chicago, Illinois.

April 4-6—**American Petroleum Institute,** Division of Production, Mid-Continent district, Broadview Hotel, Wichita, Kansas.

April 6-7—**American Institute of Mining and Metallurgical Engineers,** Joint AIME Student Chapter Meeting, Oklahoma A. & M., Stillwater, Oklahoma.

April 9-10—**Ninth Oil Recovery Conference,** a symposium on "Natural Gas in Texas," sponsored by Texas Petroleum Research Committee, Texas Memorial Student Center, Texas A&M College, College Station, Texas.

April 11-13—**Natural Gasoline Association of America,** annual, Texas Hotel, Fort Worth, Texas.

April 14-19—**Petroleum Equipment Suppliers Association,** Boca Raton, Florida.

April 15-17—**Texas Independent Producers and Royalty Owners Association,** Statler Hilton Hotel, Dallas, Texas.

April 18-20—**National Petroleum Association,** semi-annual meeting, Cleveland Hotel, Cleveland, Ohio.

April 18-20—**American Petroleum Institute,** Division of Production, Rocky Mountain district, Cosmopolitan Hotel, Denver, Colorado.

April 19-20—**West Texas Oil Lifting Short Course,** annual, Texas Technological College, Lubbock, Texas.

April 19-21—**Indiana Gas Association,** French Lick Springs Hotel, French Lick, Indiana.

April 23-25—**Southern Gas Association,** convention, annual, Statler Hilton Hotel, Dallas, Texas.

April 23-26—**American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists,** annual meeting, Conrad Hilton Hotel, Chicago, Illinois.

April 25-27—**American Petroleum Institute,** Division of Production, Eastern district, Statler Hotel, Deshler-Hilton Hotel, Columbus, Ohio.

April 25-29—**World-Oil Exposition,** Houston, Texas.

April 26-27—**American Institute of Electrical Engineers,** national meeting, Bradford Hotel, Boston, Massachusetts.

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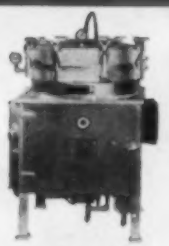

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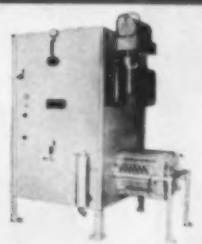

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Furnished in capacities from 0.1 to 750 gpm. Various cartridges available for mineral and inhibited detergent oils.

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May 1-3—**Petroleum Industry Electrical Association and Electrical Suppliers Association,** annual conference and exhibits, Statler Hilton Hotel, Dallas, Texas.

May 4—**Annual Conference for Engineers,** Ohio State University, Ohio Union, Columbus, Ohio.

May 6-9—**Liquefied Petroleum Gas Association,** convention and show, Conrad Hilton Hotel, Chicago, Illinois.

May 6-9—**American Institute of Chemical Engineers,** Roosevelt Hotel, New Orleans, Louisiana.

May 10-11—**American Gas Association** gas supply, transmission and storage conference, Conrad Hilton Hotel, Chicago, Illinois.

May 10-11—**American Petroleum Institute,** Division of Production, Pacific Coast district, Statler Hotel, Los Angeles, California.

May 14-15—**American Institute of Mining and Metallurgical Engineers,** Formation Fracturing Symposium, Wichita, Kansas.

May 14-16—**American Petroleum Institute,** Pipe Line conference, Shamrock Hotel, Houston, Texas.

May 14-16—**Petroleum Electric Power Association,** 27th annual meeting, Driscoll Hotel, Corpus Christi, Texas.

May 14-17—**American Petroleum Institute,** Division of Refining, midyear meeting, Montreal, Canada.

May 15-17—**Purdue Industrial Waste Conference,** Purdue Memorial Union, Lafayette, Indiana.

May 17-18—**American Institute of Mining and Metallurgical Engineers,** joint meeting of Rocky Mountain Petroleum Sections, Gladstone Hotel, Casper, Wyoming.

May 22-24—**Pennsylvania Gas Association,** Pocono Manor Inn, Pocono Manor, Pennsylvania.

May 24-25—**Natural Gas and Petroleum Association of Canada,** Sheraton Brock Hotel, Niagara Fal's, Ontario, Canada.

May 30-June 1—**Short Course in Gas Technology,** annual, Texas College of Arts and Industries, Kingsville, Texas.

May 31-June 2—**Interstate Oil Compact Commission,** mid-year meeting, Statler Hilton Hotel, Dallas, Texas.

June 17-22—**Creative Engineering Seminar,** The Pennsylvania State University, University Park, Pennsylvania.

June 17-22—**American Society for Testing Materials,** Pacific Coast meeting, Hotel Statler, Los Angeles, California.

June 25-29—**The American Society for Engineering Education,** annual meeting, Iowa State College, Ames, Iowa.

June 26-29—**Canadian Gas Association,** Manoir Richelieu, Murray Bay, Quebec, Canada.

Sept. 9-12—**American Institute of Chemical Engineers,** William Penn Hotel, Pittsburgh, Pennsylvania.

Sept. 10-14—**International Congress on Catalysts,** Bellevue-Stratford Hotel, Philadelphia, Pennsylvania.

Sept. 11-13—**Pacific Coast Gas Association,** annual meeting, Coronado, California.

Sept. 12-14—**Third Annual Electrical Conference of the Petroleum Industry,** sponsored by American Institute of Electrical Engineers and Kansas City Section of AIEE, Kansas City, Missouri.

Sept. 16-22—**American Society for Testing Materials,** Pacific Coast meeting, Hotel Statler, Los Angeles, Ca'ifornia.

Sept. 17-21—**Instrument Society of America,** annual, Instrument-Automation Conference and Exhibit (International), New York Coliseum, New York City.

Oct. 1-5—**American Institute of Electrical Engineers,** Morrison Hotel, Chicago, Illinois.

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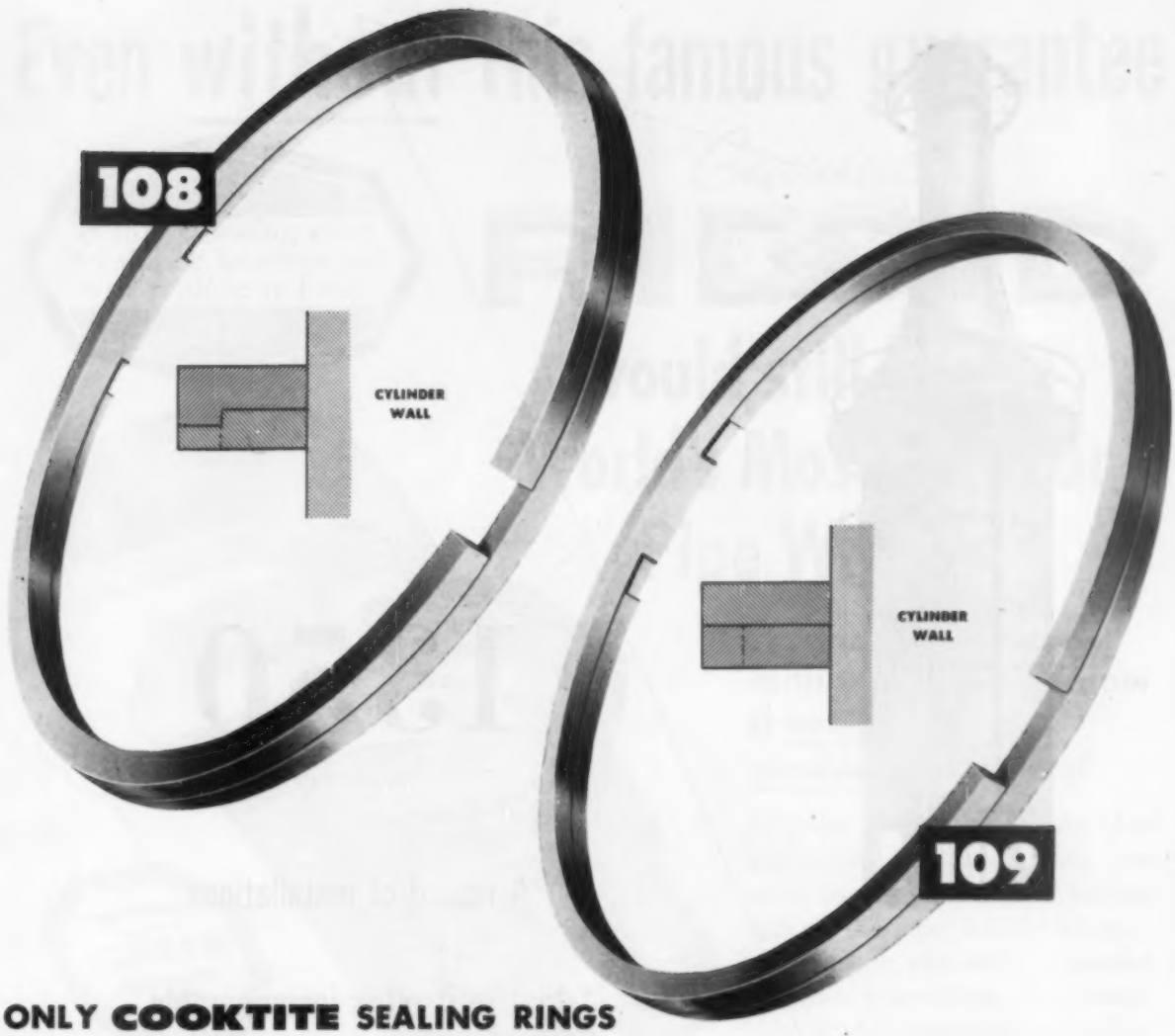

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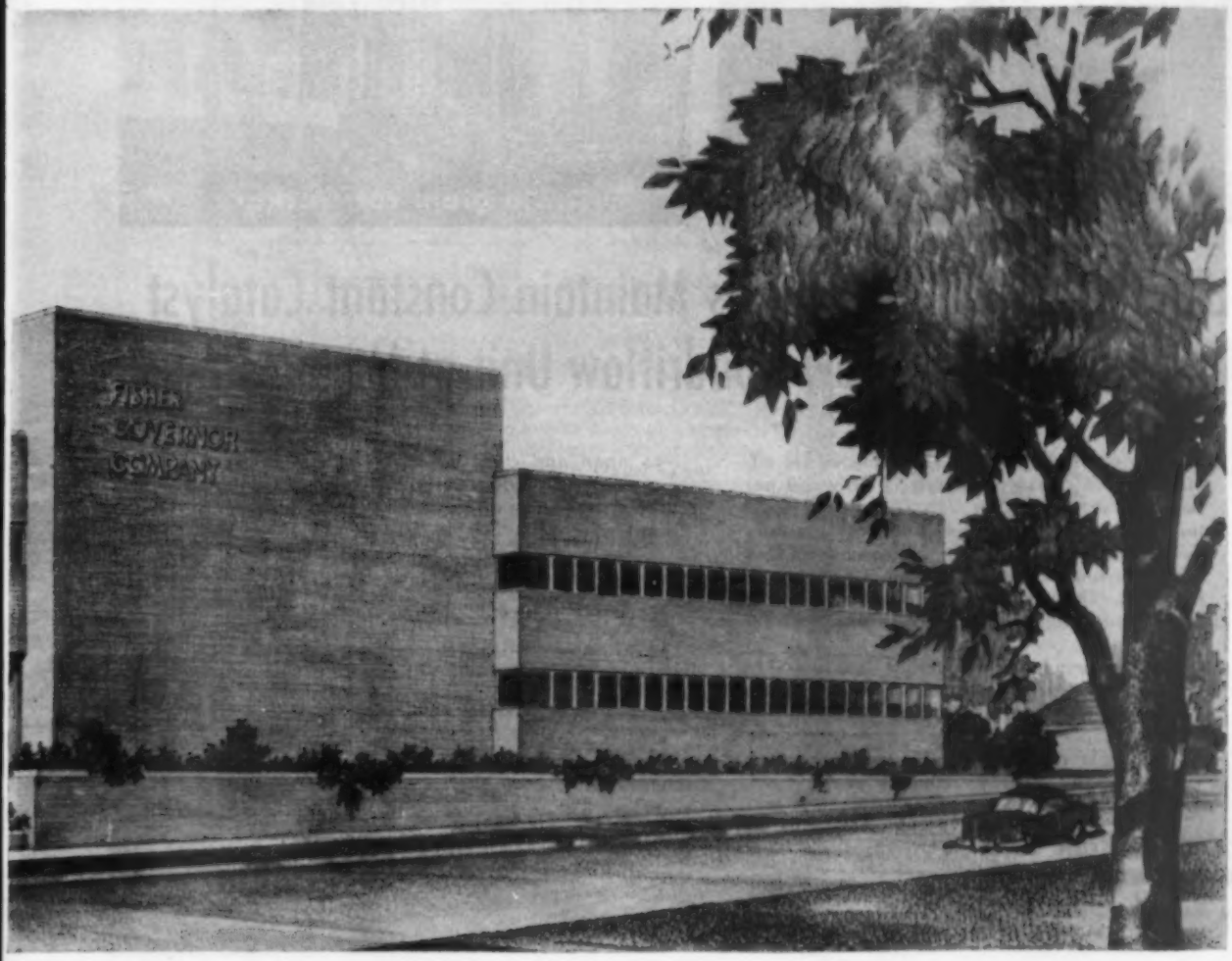

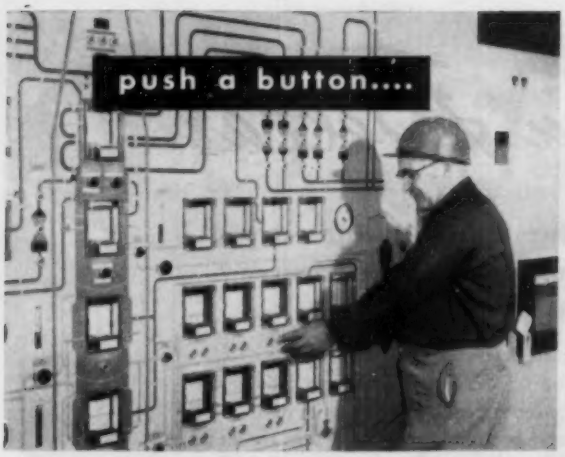

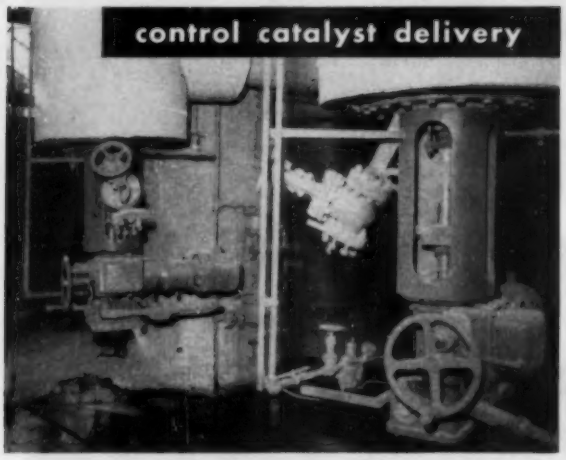

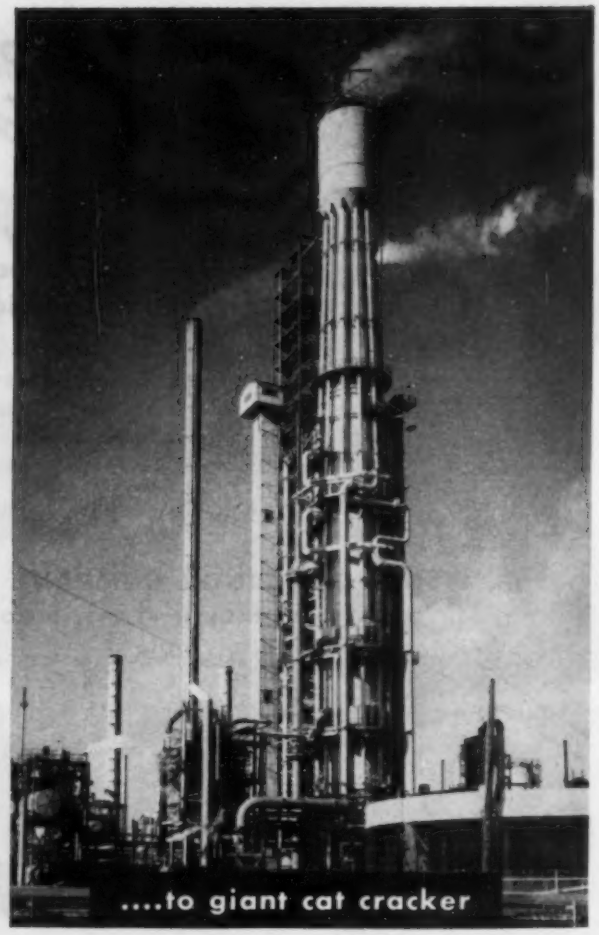

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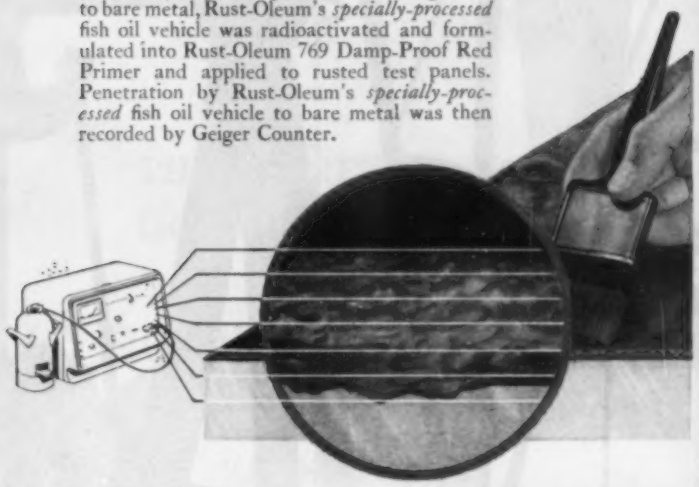
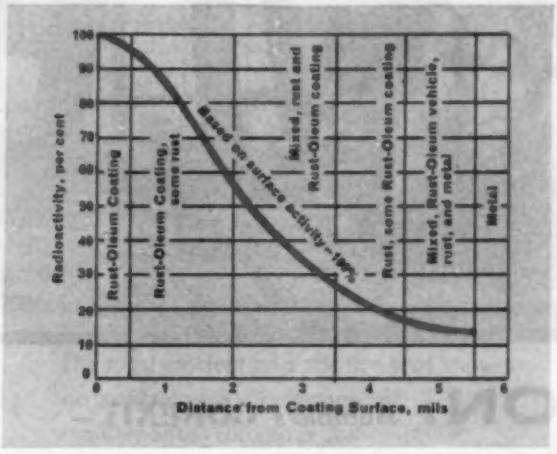
To trace Rust-Oleum penetration through rust to bare metal, Rust-Oleum's *specially-processed* fish oil vehicle was radioactivated and formulated into Rust-Oleum 769 Damp-Proof Red Primer and applied to rusted test panels. Penetration by Rust-Oleum's *specially-processed* fish oil vehicle to bare metal was then recorded by Geiger Counter.




Radioactivity, per cent
Rust-Oleum Coating
Rust-Oleum Coating, some rust
Based on surface activity = 100%
Mixed, rust and Rust-Oleum coating
Rust, some Rust-Oleum coating
Mixed, Rust-Oleum vehicle, rust, and metal
Metal
Distance from Coating Surface, mils

It's easy to actually see Rust-Oleum penetration through rust to bare metal by following the curved line on the graph above. The curved line illustrates Rust-Oleum *penetration* at each mil level down to bare metal as recorded by Geiger Counter and Gas Flow Proportional Counter.

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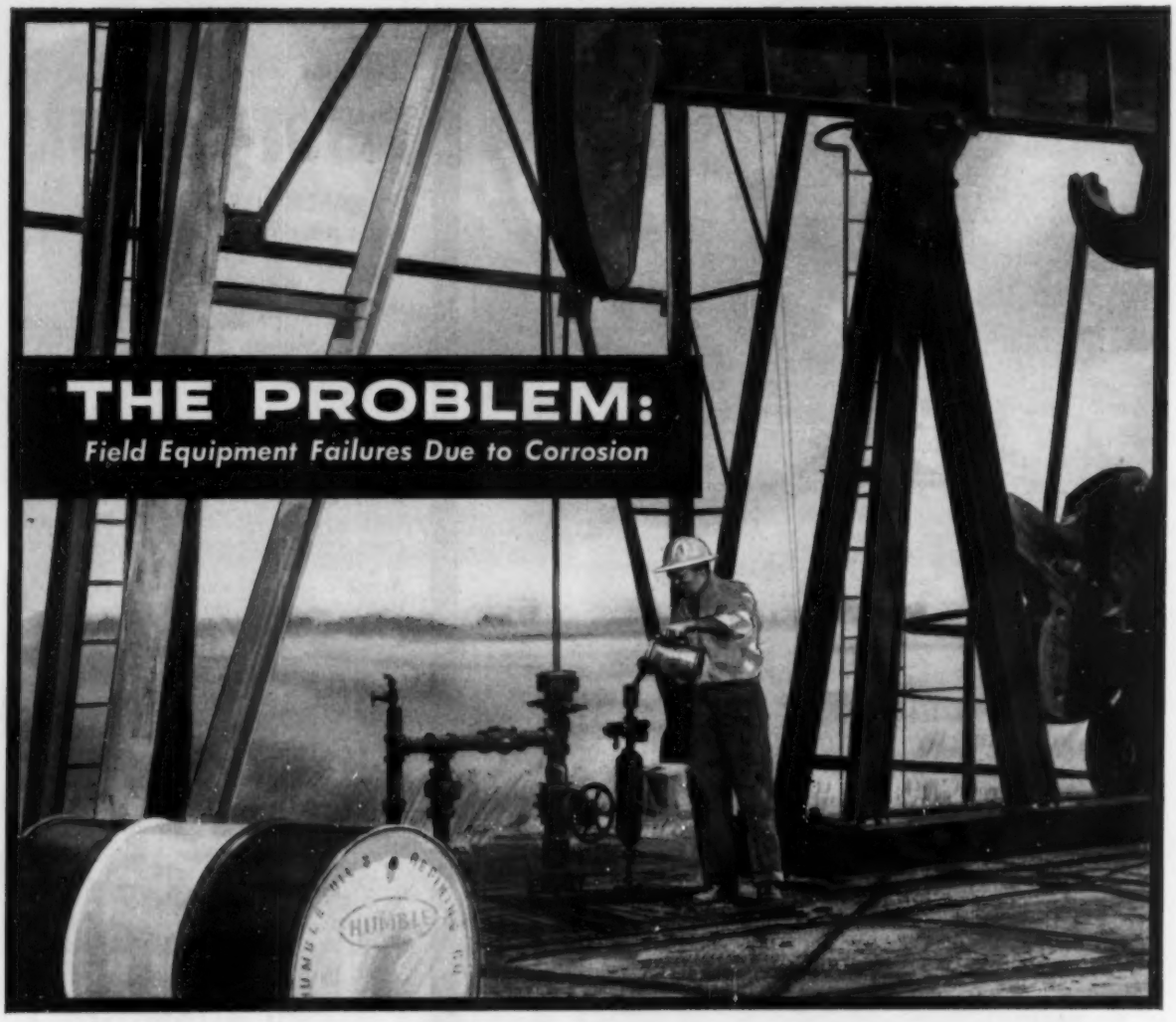

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Corexit treatments give sucker rods and tubing positive protection against corrosion and hydrogen embrittlement, even in sour crude wells. *Corexit* cleans your sub-surface equipment, loosens scale and displaces moisture on the metal surfaces. Then it builds up a tenacious and lasting protective film on these clean metal surfaces to prevent further corrosion.

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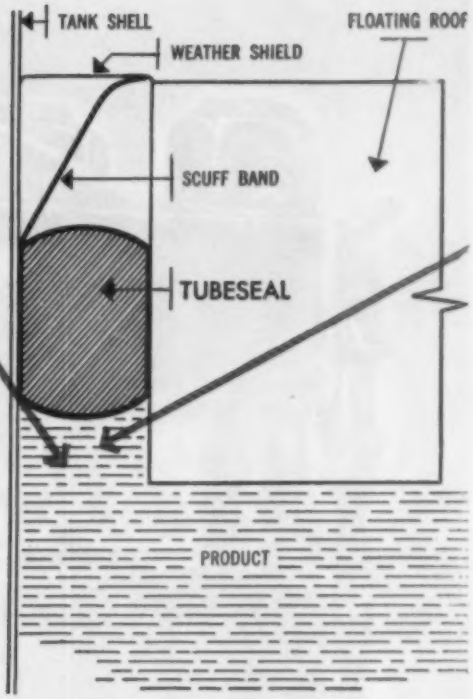

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*NO EVAPORATION
NO FIRES
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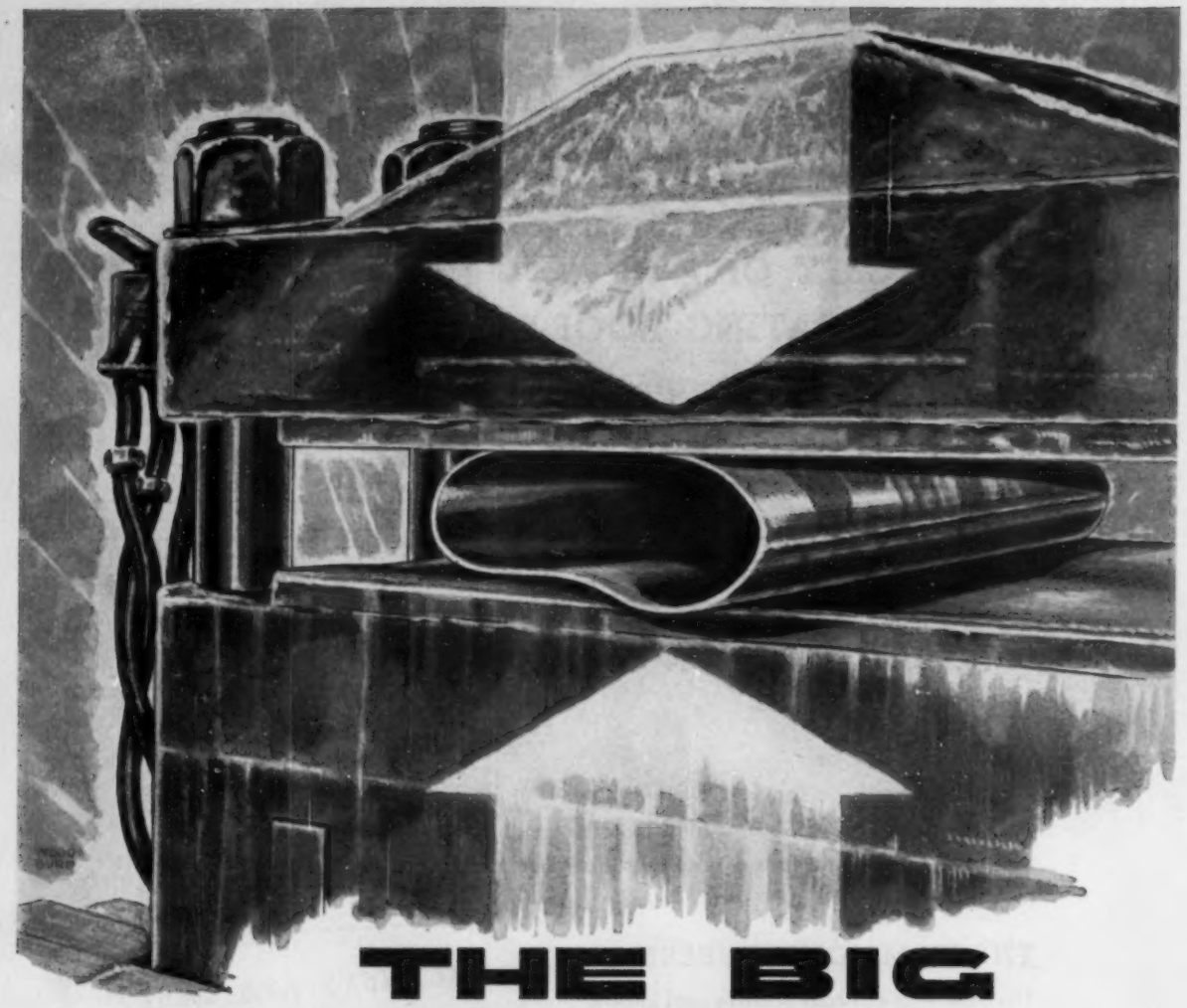

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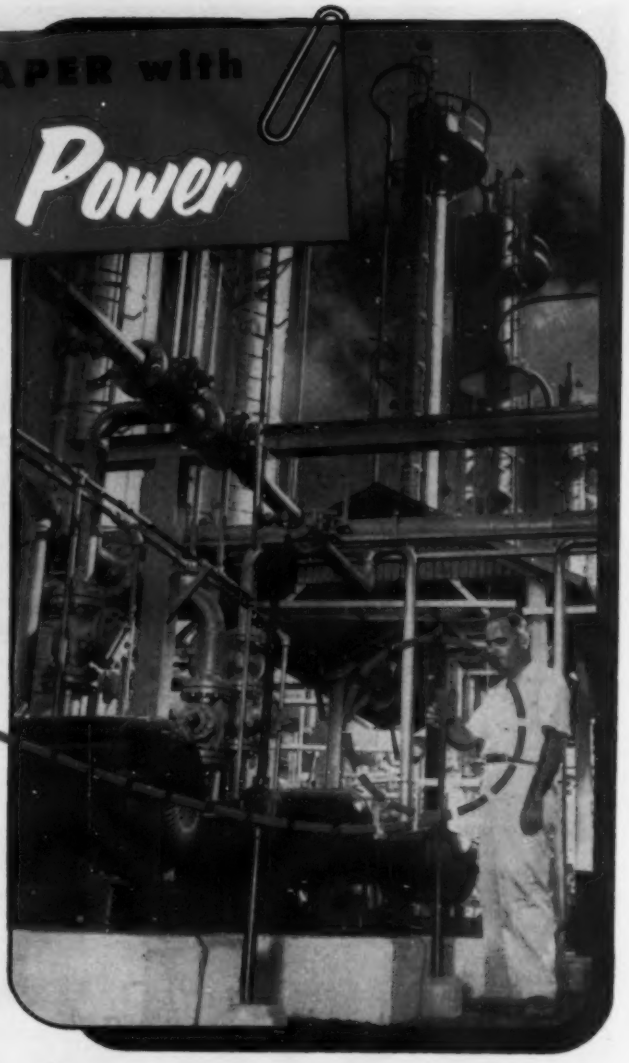

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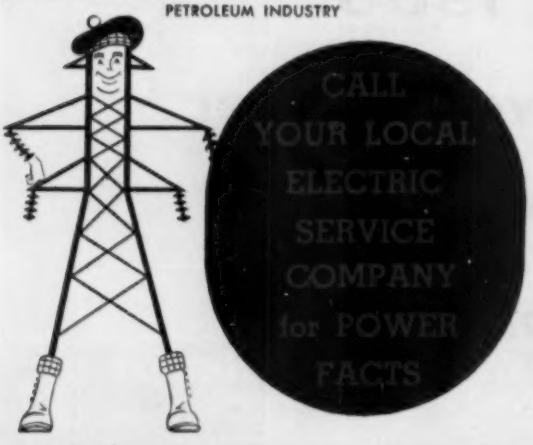

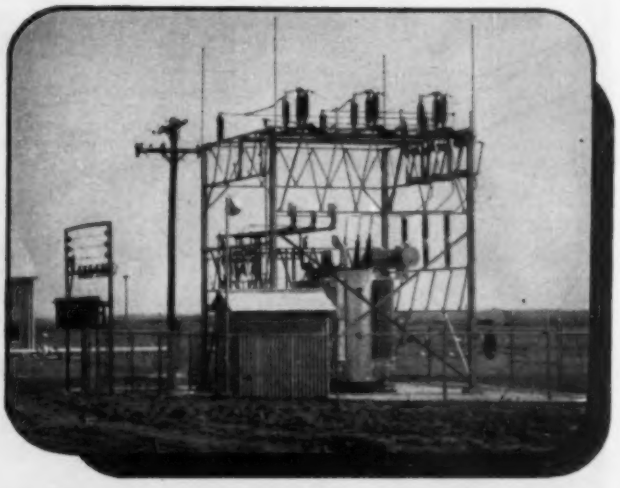

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In the stainless steel check valve unit, a transverse pin holds two balls in their seats. When the valve is properly adjusted and lubricated, there is no chance for line pressure to get into the lubricant system.

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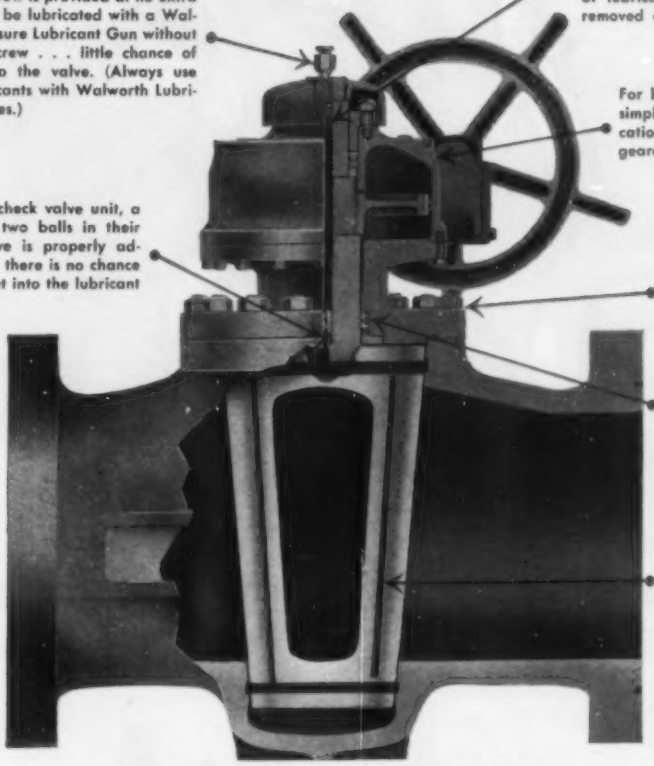

Two overlapping Teflon packing rings form an effective seal against possible leakage without "grabbing" the plug shank. Low breakout torque . . . plug turns easier. Packing serves only as a seal and is not used to hold the plug in its seat.

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Cutaway of a 24-inch Walworth Lubricated Plug Valve

Without exception, a Walworth Ball Bearing Lubricated Plug Valve is easier to operate and maintain than any other type of rotary-action, sealed valve available today for pipeline service. Design features pointed out here show just a few advantages of Walworth Ball Bearing Lubricated Plug Valves.

Many pipeline companies throughout the world use Walworth valves for handling gas, crude, and finished products. Investigate the line of Walworth valves for your own needs. See your Walworth Distributor, or write for literature: Walworth Company, General Offices, 60 East 42nd Street, New York 17, N. Y.

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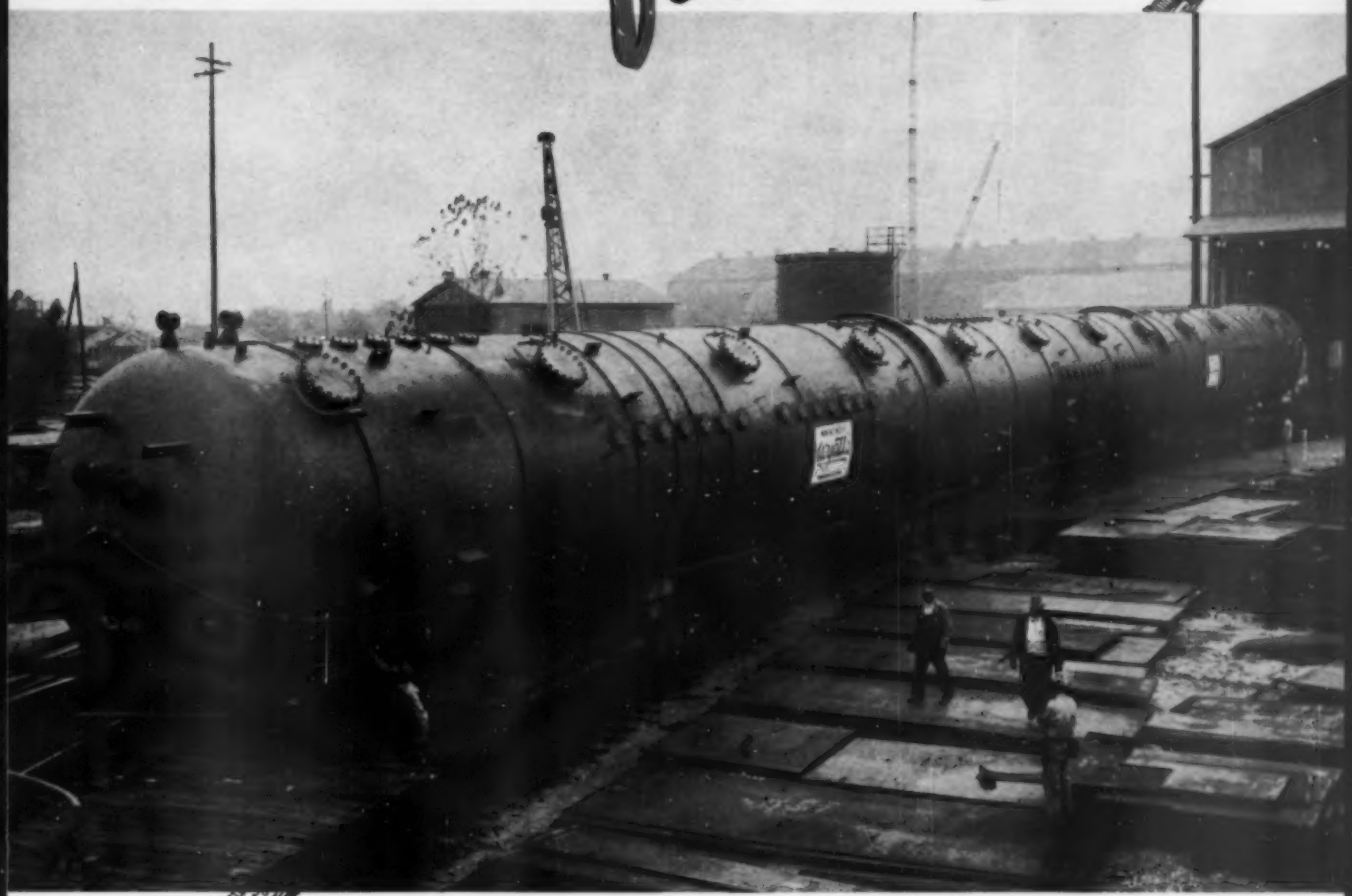
Rail Record for Length



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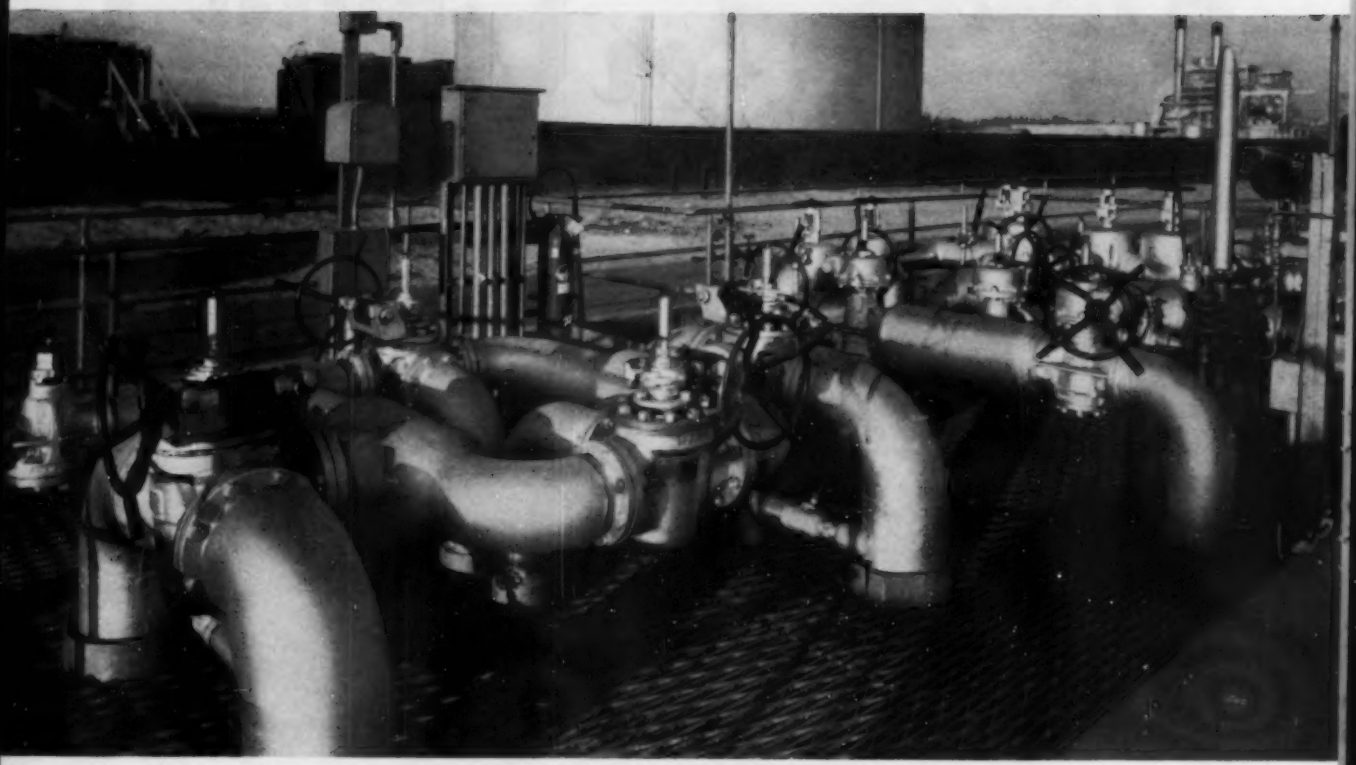

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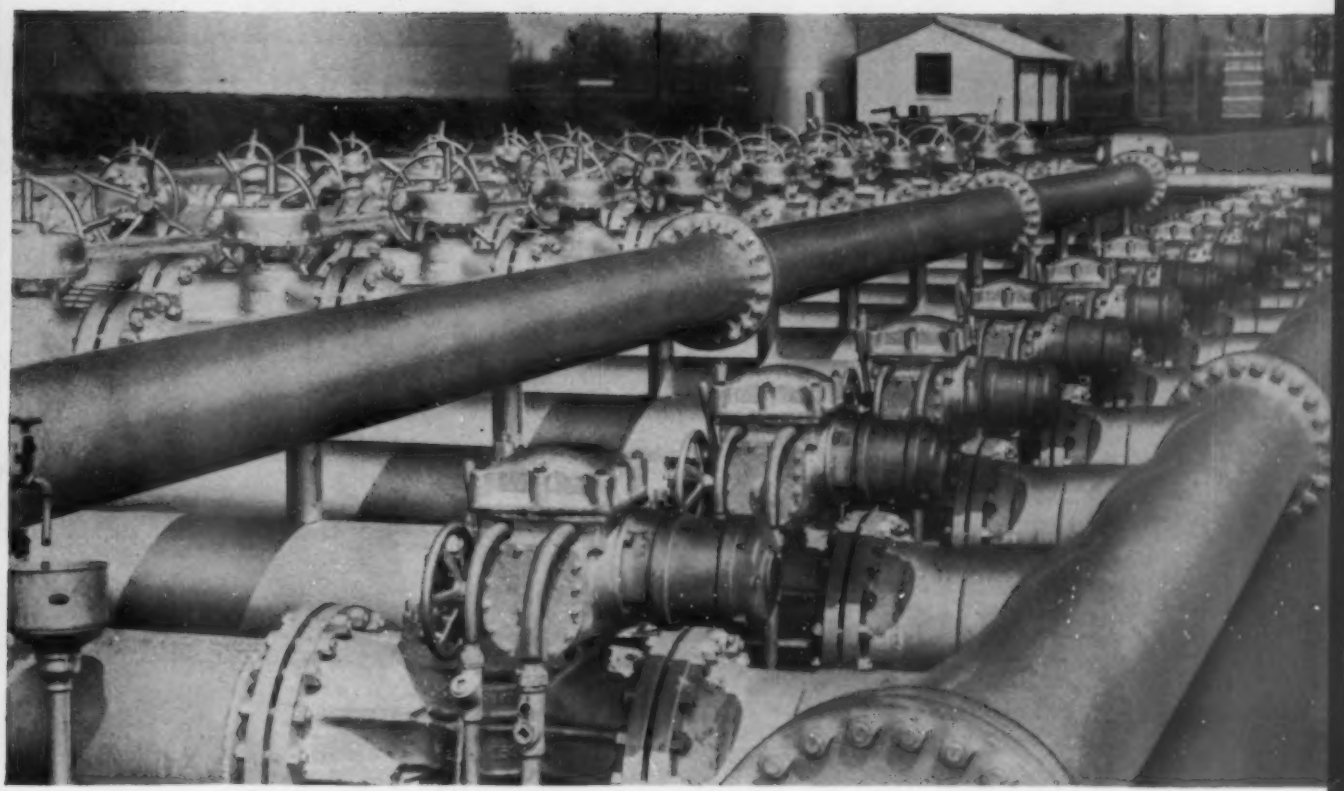
ROCKWELL-Nordstrom VALVES

Lubricant Sealed for Positive Shut-off

40th Year *of lubricated plug valve leadership*



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ROCKWELL-Nordstrom VALVES

Lubricant Sealed for Positive Shut-off

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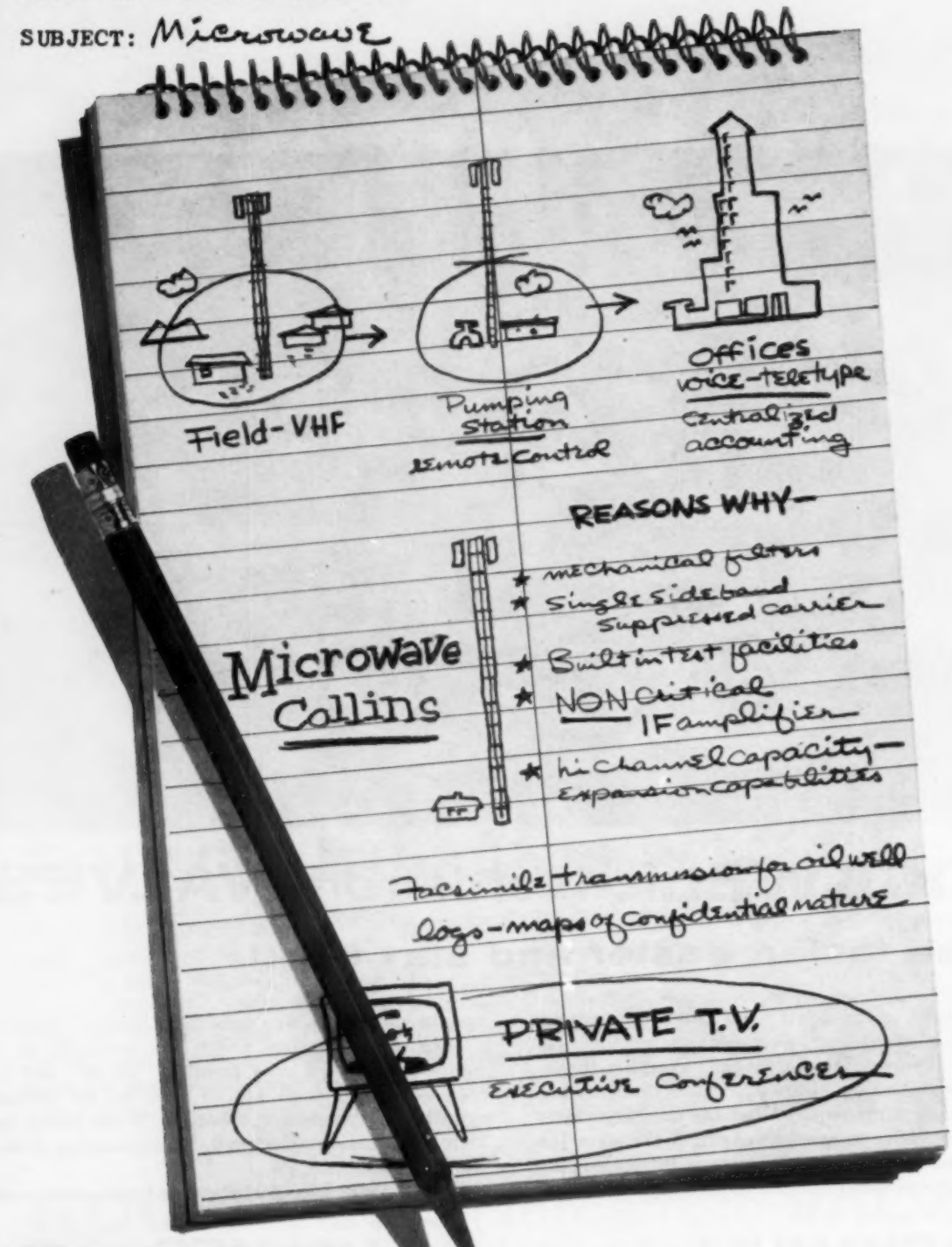

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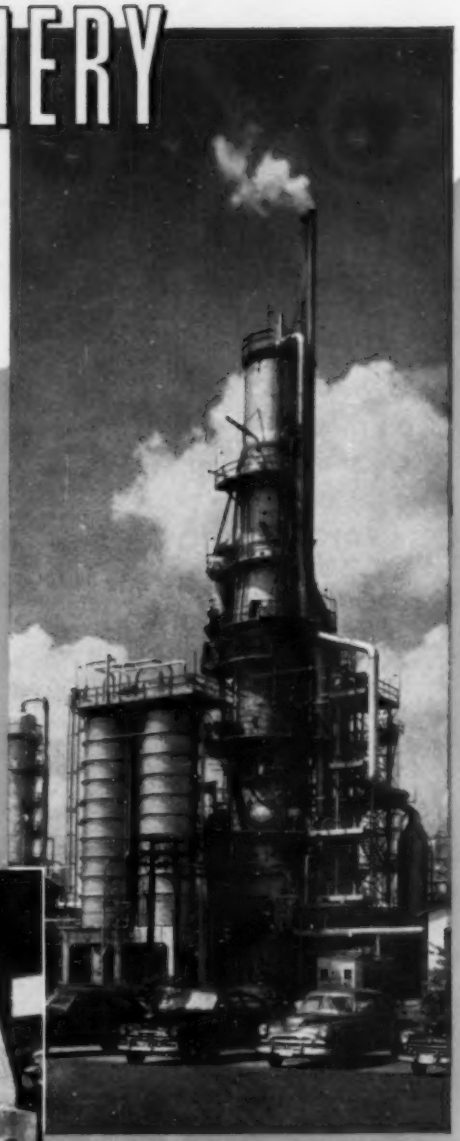

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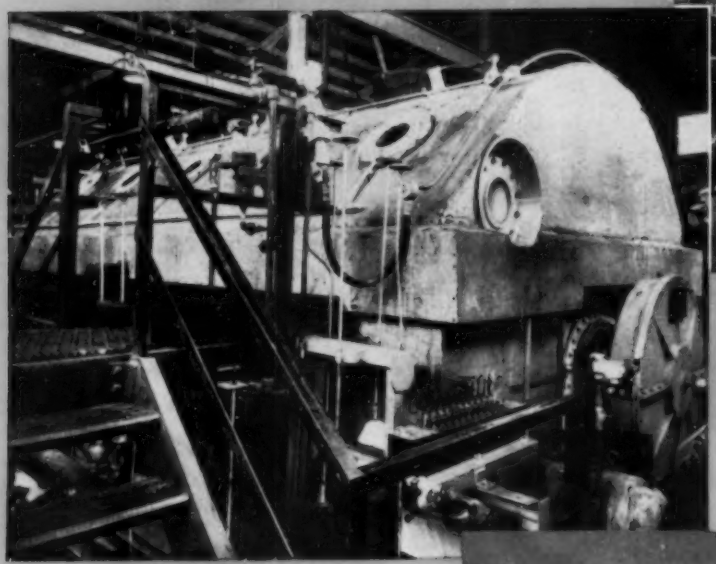

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The *Petroleum* ENGINEER
March
1956

Business and industry have tried "efficiency experts," all kinds of benefits in addition to salary, and now ventures into a field of morale-building. . . . It's a challenge because we actually don't know . . .

What Makes a Man Work?

A. Q. Sartain

ONE of the things that characterizes modern business and industry is an interest in problems of human relations. On every hand, we find "training" for supervisors and "development" for executives, and seldom do we find one of these programs without a considerable emphasis on the human relations skills involved in these jobs. How to work with people and get the best from them is certainly recognized as one of the problems of modern business and industry.

This has not always been so. As a matter of fact, it was not so until recently. All of us can remember when the human relations aspect of a business were little considered, if not actually neglected. Let us look first at some of the attitudes that have been held toward the human relations aspect of a job.

Efficiency Method

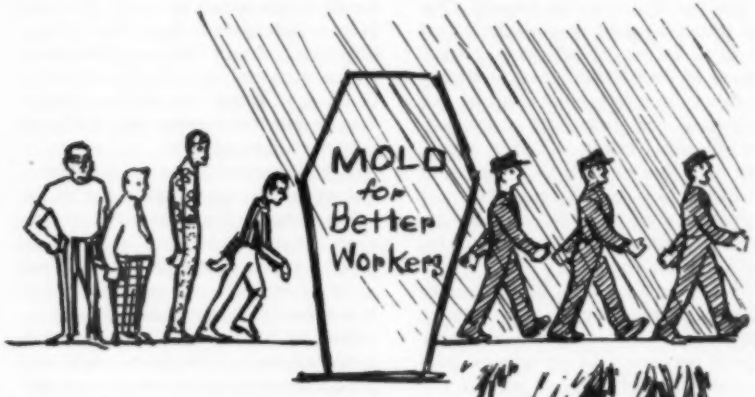
One of the attitudes that people have held toward the worker is that of seeing him as essentially a part of the machine, or perhaps better, a part of the method of "getting the job done." Indeed, until World War II, this attitude was largely characteristic of business and industry.

There is probably no better illustration of the point than the movement known as *"scientific management."* "Scientific management" attempted to put into the blueprint or the machine the judgment and the skill that once went with the job. Or if it were not feasible to put it in one of these mechanical devices, it was relayed to the expert. The expert, of course, was placed as high in the organization as it was practicable to place him, considering the decisions he had to make, and he was supposed to be just that—an expert in making decisions along this particular line. And problems that were related to many jobs were put in his hands, insofar as that was practicable.

The worker, on the other hand, was trained in the *best method.* In other words, he was trained to do what he was supposed to do, in the way in which he was supposed to do it, with a maximum of efficiency—that is, with as little loss of time and energy as practicable. Indeed, the feeling was prevalent 20 years ago that, if you provided for a man good methods, good materials, good machines, and good working conditions, you had done about all that could be done so far as the human relations problems were concerned. This was especially true if you added to these good things incentive-type wage payments.

Now we are all aware of the fact that this has not worked out too well. The unhappiness of workers expressed itself directly in the rejection of the "efficiency expert" and his methods. Somehow people are never quite satisfied with procedures of this sort.

Actually, it should not be very hard to understand this situation because people are never content to be merely cogs in a machine, merely machines in a process of production. Every person wants to be treated as a human being. He likes to be thought of as a creature of value; he feels that he is a person who should be treated with dignity and



◂ "Scientific management" moulded workers to fit efficiency patterns.

After W W II "keep 'em happy" method cushioned worker with all kinds of fringe benefits. ▸

respect. And however well you care for a machine, however you keep it oiled, repaired, and adjusted, you can hardly say that you treat it with dignity and respect.

And thus, we see that whatever it takes to get along well with people in business and industry, it is not sufficient simply to see the individual as a part of the process of production and to try to "engineer" him into the job and efficient operation.

Keep 'Em Happy Formula

"Keeping them happy" is the second attitude that we would like to discuss for a moment. We all remember what happened with the coming of World War II. It was hard to find enough people to fill all the jobs that we had to fill, and sometimes even more difficult to keep them after we got them. We started into a program of what we now refer to as fringe benefits, or perhaps a little more broadly, benefits and services, and attempted as best we could to keep people happy by means of what we could give them.

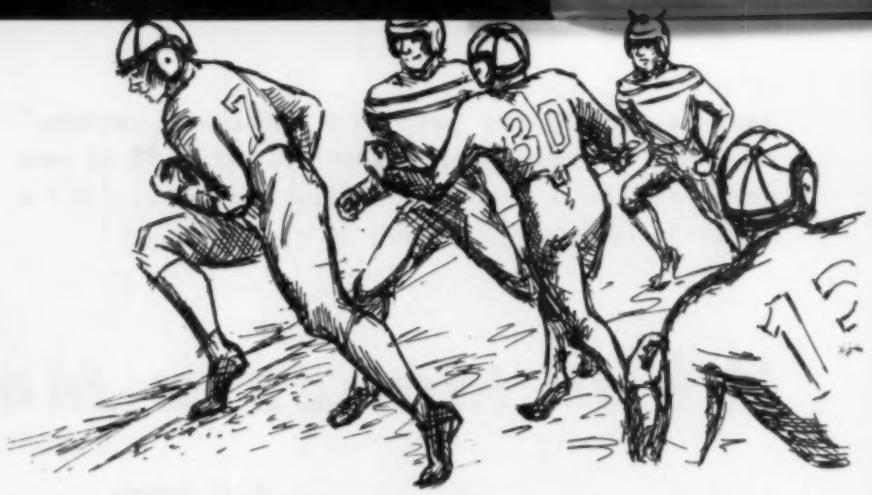
It's interesting how much we did during and since World War II to give things to people and try to keep them interested in their jobs. To mention just a few, there are pensions, hospitalization insurance, group life insurance, credit unions, suggestion systems, music-while-you-work, house organs, organized recreational programs, vacations, and personnel counseling. Often, all these and more were provided in an attempt on our part to "keep them happy" in times of critical labor shortage.

It may very well be that the "keep 'em happy" philosophy was not essentially different from the actual philosophy of "scientific management," but in any case, instead of concentrating on the individual as a machine, we very much wanted him to do at least the minimum, and we felt that somehow we must do things for him to bring about this result.

Before we leave this point, perhaps a word of evaluation with regard to these two methods would not be out of order. For one thing, we must understand that the worker at whatever level in the business, from the executive on down, actually is a part of the process of production and must be recognized as such. There is certainly no excuse for using inefficient methods if more efficient methods are available. But it must never be forgotten that one very important consideration in this regard is the *feelings* of the worker himself. One who prides himself on considering all the facts before he adopts a certain method of production or of rendering service or of selling must consider the feelings of the individual concerned. The efficient worker, in other words, must hold himself in high regard, and he must be held so by his boss. He must be evaluated not only for what he can do for the company, but as well for his worth as an individual.

Obviously, we cannot be opposed to keeping people happy, but keeping them really happy is not nearly as simple as it may seem. In my opinion, people can be too happy, at least in the sense of being too contented. Actually, ambitious people are probably never happy in this sense of the term, and there is some evidence, particularly from studies done by the University of Michigan, that the better workers are not always the happy workers. At least, better workers are probably more likely to be critical of the company and critical of the job that they have to do, and definitely more disturbed by inefficiency when they find it. If this is true, these people are also going to be less influenced by an elaborate program of benefits and services.

Of course, we need more information on this point than has been accumulated up to the present time, but at any rate, we can say that proper engineering and keeping them happy are not the whole story. They may be important parts of the story, but there is more to it than simply these things.



Team spirit is as vital for a healthy organization as it is for a championship team.

The Nature of Morale

It is easy to get the idea that the most dependable conclusion about human beings is that they are out for themselves and indeed that the only way to get people to work hard is to show them what there is in it for them individually. On the other hand, it certainly should be noted that there are situations in which this point of view hardly seems to tell the story. In some human endeavors at least, we find enthusiasm, a desire for accomplishment, and a sense of devotion hard to account for on the assumption that it's "every man for himself and the devil take the hindmost."

Athletic teams are a good example. Not all athletic teams have what we are talking about, but successful athletic teams have it—unless indeed, by greatly superior manpower they can simply overwhelm the opposition with talent. Every coach wants men who are willing to subordinate their own ends to the interests of the team—men who have a fierce desire to win and see to it that the school, or at least the team, stands out in athletic competition.

The truth of the matter is that in athletics the man who participates for the purpose of getting glory and publicity for himself alone is usually not successful. Great players usually come from great teams, and great teams usually have great team spirit. The best men in the sport, whether it be football, baseball, basketball or any other, are usually men who have an intense

The Author

Dr. Aaron Quinn Sartain is professor of psychology in the College of Arts and Sciences at Southern Methodist University, Dallas, Texas, and is chairman of the department of personnel administration in the SMU School of Business Administration.

He received his BA degree from SMU in 1928, his MA in 1930 and was awarded a PhD from the University of Chicago in 1939.

A fellow of the American Psychological Association and of the American Association for the Advancement of Science, Dr. Sartain is a former president of the Texas Psychological Association and is now president of the Southwestern Psychological Association. He is a member of many honorary societies, including Phi Beta Kappa, and a number of working organizations such as the American Arbitration Association.

loyalty to the team of which they are a part. They have a great deal of willingness to serve and sacrifice for that team.

The church furnishes us another example of the same sort—not all churches, of course, for churches may be divided and in conflict, or like other organizations, they may simply "coast." But we have all observed in many churches a great deal of devotion and enthusiasm and willingness to be of service, and it is interesting that the question "What is there in it for me?" while it may appear from time to time, is certainly not the main motivating force for most of the members.

Civic enterprises likewise furnish an example of the thing we have in mind. It may be a service club, or a school board, or even a chamber of commerce, but in all these you usually find a great many people who are devoting their time and energy to improving the community, or some particular organization in the community. The member may gain — and some people may become members of the organization for the purpose of gaining—but it is interesting how frequently even those who join in order to gain after awhile find that they have become identified with the activities of the organization and wholeheartedly pursue its aims, asking no other reward than that of being of service to this worthwhile endeavor.

It certainly would be a mistake not to note that this may also happen in business and industry. In fact, it has happened in many organizations. Here is one, for example, in which service pins are proudly worn. The worker's family is brought to the yearly open house with a great deal of pride. The name of the company and the company products are defended, and the people in general show loyalty and enthusiasm for the organization.

It will have to be admitted, of course, that organizations vary enormously in this regard, some having little or none of it and others having a sense of devotion that would be hard to match even by athletic teams or service clubs.

Now just what is the nature of this feeling of devotion? What is it that we are dealing with when we talk about the enthusiasm and loyalty of a group of individuals? This is what I would like to call morale; indeed, I think this is the heart of morale. Just what is the meaning of the term *morale?*

Morale, it seems to me, represents the willingness of the individual to subordinate his own desires to the aims of the group with which he has been identified. Morale is primarly a group thing; that is to say, it is a thing typically shared with other people, and unless most people in a group feel that way, it is difficult for a few to maintain a state of high morale. And yet, at the same time, morale is an individual thing, for only individuals have feelings or thoughts or aims or a spirit of devotion. Morale, then, is an enthusiasm for attaining a group objective. It often shows itself by hard work in the face of adversity, but there are various ways in which devotion of the individual to the aims of enterprise shows itself.

In some quarters, there is a great deal of skepticism about the possibility of attaining this kind of feeling. Especially in business and industry there has been a tendency to emphasize the selfishness of human beings, the desire to get for ourselves and make the aims of other people secondary. Indeed, there are those who would hold that self-seeking is inevitable, and an economic philosophy of not long ago, stressing enlightened self-interest, would try to brand the thing we are considering a virtual impossibility.

Even those who admit the possibility of his sense of devotion or high morale in a business organization often insist that, while it may happen to certain individuals and under certain circumstances, in general it does not occur with sufficient frequency to be practicable in the work situation. Here the argument runs that since people are essentially out for themselves, any attempt to make any other appeal to them will ultimately fail.

There is a great deal in popular thinking to support this line of reasoning. In many quarters, the view has long been held that people work because they have to and not because they want to, that work is essentially unpleasant, and, indeed, that unless one was compelled to work for himself and his family, he would not be working in the first place.

I confess that I cannot accept this line of reasoning as inevitable for all or even a majority of those of us who work. It goes without saying that sometimes we are selfish when we work and really do not care what other people say or think unless it affects us adversely. But it seems to me that this is in no sense inevitable, and one who does not recognize the possibility of devotion to duty in the area of work not only is doomed to pessimism but is also being unrealistic and simply failing to take into account the actual facts. Indeed, I would go far enough to say that this ability to bring people to identify themselves with the organization and invest their lives in it is an *essential* part of what we call the American way of life. And difficult as the ask may be, in it lies the real hope of the future.

How to Increase Morale

Considering its importance, we know very little about the nature of morale and how to increase it. Indeed, as we have suggested earlier, it is only within recent years that we have become definitely interested in the subject—if indeed most of us are now. There are probably no universal methods of building morale, but the following suggestions may represent at least a start in that direction.

Don't supervise subordinates any more closely than you need to. People don't like to be watched—at least not in the objectionable sense of that word. This is true of a child in relation to his parents, or of an athlete directed by his coach, or of a worker under the supervision of his foreman. People like to feel that the parent, or the coach, or the boss has confidence in them. They like to feel that, at least to some extent, they are self-determining and that they may do their jobs in their own way, provided they do these jobs well.

Sometimes, it must be admitted, you have to supervise closely because the people are either unable or unwilling to work independently. We have all seen situations in which people simply could not be trusted out of the sight of the boss, at least not for very long periods of time. Under these circumstances, that is, if your group is such that it has to be watched, you will have to watch it. If close supervision is required to "get the goods out the door," then close supervision is what you have to furnish. But it's very important to realize that a modern supervisor not only has the job of supervising but should have as an ideal the time when it will not be necessary to supervise as closely as at present.

The truth of the matter is that the time-honored belief in America is that people are dependable—that they can be trusted—and that when you trust them, good results follow. Certainly we must confess that the ingenuity and determination and skill of the ordinary worker in business and industry in America are at least partially responsible for our great progress. It is traits of this sort, it seems to me, that we need to encourage. The ideal, indeed, would be a self-determining group—one in which everyone did what he was supposed to do when he was supposed

Don't over-supervise.

to do it in the way he was supposed to do it, because he wanted to and not because he had to.

Obviously, this ideal is seldom reached in practice. But it is amazing in some instances how close people have come to attaining this particular objective, and satisfying indeed are the rewards that come from such a situation. It must never be forgotten that even a little progress along this line pays large dividends.

Keep them informed about matters in which they are interested. If there is anything true about the modern American at whatever level in a business organization, it is that he wants to know. He wants to know about all sorts of things. He wants to know about the company; he wants to know about its plans; he wants to know what is happening to individuals in the business. He *wants* to know—and the interesting thing is that he probably *will*. Whether he is told directly or gets it from the grapevine or some other source, he will probably contrive to find out.

Faced with this situation, would we not be wise in most cases to recognize not only the desire to know but the fact that workers will come to know, and try to satisfy their curiosity in a direct and honorable fashion?

It is very important to recognize that people want to know the "why" of a decision as well as the "what." In other words, it is not sufficient in most instances to tell people simply *what* you have decided. Nearly always they want to know *why* you decided what you decided. Perhaps it would be worth mentioning also that they are probably equally concerned about the ideals and values that lie behind a decision. Here, I suspect, we may have done a poorer job even than we have in some other aspects of communication, that is, in failing to communicate adequately *why* we decided and the character and ideals and aspirations of the people who make these decisions.

Now it would be naive if we did not recognize that this matter of keeping people informed can be overdone. There are things in organizations that from time to time may better be kept secret. Telling all you know to everyone may give competitors a great advantage, or, what is much more likely, it may lead to false hopes or to implied promises that can't be kept or even to confidences betrayed. Anyone who does not recognize this situation and take it into account is certainly not being wise in his supervision of people.

Keep employees informed.

But it is important to recognize that many more mistakes have been made by management by not communicating enough, than have been made by communicating too much. Even for things for which people don't need to know, they would very much like to know *why* they do not need to know them.

Consult with them. It is easy for management to get the idea that if people are kept informed about the things in which they are interested, management has discharged its responsibility along this line. I wish that were true, because though it is difficult to communicate effectively with people, it still is less difficult than some of our other responsibilities. The truth is that with the tradition that has grown up in America—with the emphasis on the dignity and worth of the individual and his freedom in making decisions at the ballot box and in education and marriage and church membership and the like—simply to keep people informed isn't enough.

The fact is that Americans want opportunities to "get into the act." They want opportunities to make suggestions; they want their ideas earnestly and sincerely sought. And they want these ideas and suggestions carefully considered before action is taken.

There is a great deal of doubt in my mind as to whether morale can be high in an organization without something of this feeling. It is apparent, of course, that we are not saying here that there must be a show of hands and a majority vote before a decision is made. What we are saying is that there must be a consulting with people—not on every decision that comes up, because some matters are trivial and others represent emergencies where there is no time available for consulting with others—but on many matters that affect them. A management that does not afford this sort of participation to the people in it, whether they be management or rank-and-file, is, it seems to me, treading on extremely dangerous ground.

The interesting thing about the suggestions we get from our subordinates is how good many of them actually turn out to be. It is an actual fact that many an excellent idea comes from the most unexpected source. But even if the ideas are not good, even if one suspects that a certain individual seldom if ever comes up with a good idea, how can people grow and develop beyond their present limitations unless their supervisors help them mature by giving them opportunities to make a contribution to the common good?

Consult with employees.

Understand and deal with them as a group. One of the most important emphases in human relations training in business and industry at the present time is the advice we give people to treat their subordinates as individuals. We tell our supervisors, for example, that they should know their workers — their interests, their ideals, their financial situation, their family background, etc.—insofar as this information can be obtained in a dignified and not in a prying way. This is very good advice because, unless one knows his subordinates intimately, he may quite unintentionally tread on the toes of people or hurt them without any intention of doing so.

But there is another aspect to this problem, and in the main we have overlooked it. That is the fact that you can deal with people individually in a very successful fashion and not deal with them at all successfully insofar as group relationships are concerned. People act differently in a group than they do when they are alone. We human beings are influenced by the actions of our fellows; their ideas and feelings react on ours, their enthusiasm (or unhappiness) is heightened by ours—and ours, by theirs—and in all this there is a great deal of interaction and mutual stimulation.

What we are saying, in other words, is that the wise manager has to be sensitive to group aspirations, group attitudes, and group values, and to take them into account as he deals with people. This usually demands a great many group meetings. It calls for group meetings that are well conducted, meetings in which the people feel free to express themselves even to the point of criticizing things as they are. It certainly requires a leader who knows how to listen well, one who knows how to draw others out. And he has to be one who

"can take it," for in situations of this sort criticisms will come from time to time, and some of the criticisms will be directed toward the boss.

This is a large order for many supervisors and managers. Indeed because of their lack of training and skill along this line, some may be unable to do this sort of thing successfully. But there is no question but that, other things being equal, the supervisor who is skilled at dealing with people in groups is going to be a great deal more effective in the long run.

These group meetings are an excellent way of keeping people informed because in them each person has an opportunity to express his ideas, and people can ask questions and get points of uncertainty cleared up. And it is certainly worth noting that from group situations there frequently come some of the best ideas that one can get. We have all had the experience of being in a group and, as a result of what the group says and does, being stimulated to come up with ideas better by a great deal than anything that we had thought of, or would have thought of, if we had not had group stimulation.

Don't throw your weight around. We have just indicated that almost universally the modern American resents an arbitrary decision. There are instances of this almost everywhere. When we find a person who makes an arbitrary decision, who throws his weight around, it doesn't make much difference where he is or who he is, he incurs our resentment. It may be in the church or the lodge or the club or the P.-T.A., or it may be in the work situation. As we have already indicated, Americans expect to be treated with dignity and respect. They expect decisions to be made fairly on the basis of facts and not on the basis of feelings. They expect to get their just desserts, and want their fellow workers to get theirs also. They are hurt by decisions that are made on the basis of feelings or prejudice or emotion and the like, even when they profit from them.

Here it is hard to overemphasize the importance of emotional balance and control. The supervisor who supervises in accordance with his feelings suffers greatly in loss of respect. And one who supervises in accordance with his personal likes or dislikes—one who plays favorites—soon loses whatever respect the group had for him. Even those who profit from his decisions, as we have already pointed out, lose respect for the supervisor who uses this method.

Now all of us have a tendency to feel that these matters, especially this matter of prejudice, are the other fellow's problem and not our own. We feel that we are not prejudiced, that we decide on the basis of facts, and that it is too bad that not everyone else does as we do. Actually, prejudice is everybody's problem, including yours and mine, at least to some extent. Here are two suggestions about how to deal with this matter of prejudice.

In the first place, we need to have the courage to examine our own feelings and actions. Have we really been fair, or has there been a tendency to favor those we like and to discriminate against those we don't like? If we are really honest with ourselves, most of us have to admit that there have been times when we have not been as fair as we should have been, even when our intentions may have been of the best.

In the second place, if we really want to be fair and sure that we are not influenced by prejudice, we need to be willing to check our judgment against that of another or others. Here surely, two heads are better than one. If you are right in your decisions, your boss or a member of the industrial relations department or another person in position to know will probably agree with you. Even if he does not agree, the points he brings up are worth considering, and you are in a better position to make up your own mind after hearing them. A danger here is "buck passing." We must avoid that. If it's your decision to make, you must make it.

Help them find and take advantage of opportunities to satisfy the need to be needed. One need that we are inclined to overlook in business and industry is the need to be needed. This is a very real need on the part of practically all human beings. We like to feel that what we are doing makes a difference — that we are contributing something significant to an organization that is worth while. As has been said earlier, if we ever get the notion that we are only cogs in a machine, the result is a frustrating and unrewarding experience.

Now this need to be needed is often thwarted in modern society, probably nowhere more than in the work situation, particularly if we follow the point of view that was mentioned first in this discussion, that of "engineering" the job so that the individual has a minimum of responsibility. It is so difficult to get this feeling of real importance in such a situation.

Satisfy the need to be needed.

Here is where the wise supervisor comes in. He puts forth extra effort and time and energy, as well as doing a great deal of hard study, in order to find situations where people can satisfy this need to be needed. This often requires the best ingenuity of which the supervisor is capable.

Another side to this story is that it may be almost as difficult to get people to take advantage of these opportunities to satisfy the need to be needed as it is to find such opportunities in the first place. Indeed in many instances, a leader must be a real diplomat to get people to take full advantage of these opportunities when they are offered. But nothing contributes to the best sort of happiness and to real long-run efficiency of the organization more than those situations where people do more than the minimum and do so gladly and willingly.

Here I think we make some serious mistakes. It is easy to get the idea that the best way to supervise a person is to require no more of him than you have to and to make things as easy for him as you can, considering the efficiency of the organization and his job. However, quite the contrary is the situation. Often when you can get a person to do more than the minimum for you — more than the actual requirements of the job — and do this voluntarily, that individual finds himself eventually devoted to the organization and identified with the group to a degree that few, if any other methods, can bring about.

The Challenge of Working

Actually, there is no more challenging or exciting activity than that of working with other people, and there are few fields in which the challenge is any greater than it is in business and industry at the present time. As we have already confessed, relatively little is known as yet about who to get the best from another person, but that only means that opportunities for increasing our knowledge and skill are all the greater.

The most important fact of all is that when one does increase his skill, the rewards are great to him not only in terms of improved efficiency of output and more enthusiastic workers among his subordinates, but also in the sense of personal satisfaction that comes from a feeling that one has not only turned out a good product but in the process has helped his fellow workers to become better citizens and better human beings. ★ ★ ★

Unrest Among Engineers

The scarcity of technical men is at the root of the problem, as jobhopping reaches all-time high. Here are some tips on how to hold your men

Why Engineers Quit

A west coast firm queried 96 who terminated in a year. Here's what they said; most had several reasons for leaving.

REASON	PERCENTAGE
Loss of key personnel	10.9
Ineffective administration	10.9
Lack of research contracts	10.0
Low morale of associates	7.9
Broaden experience	5.9
Talents not utilized	5.4
Lack of recognition	5.0
Growing emphasis on production	5.0
Desire for more responsibility	4.6
Seeks higher salary	4.6
Joining former associates	4.2
Desires smaller company	4.2
Lack of opportunity for advancement	4.2
Work too routine	3.4
Personality clash	3.4
Family problems	2.5
Entering military service	2.1
Dislikes personnel evaluation methods	1.7
Uncertain future of the company	1.3
Commuting distance too far	0.8
Resuming formal education	0.8
Working conditions too crowded	0.8
Entering own business	0.4

NEXT month John Smith starts the sixth job in his eight-year career as a mechanical engineer.

Jobhopper Smith tells himself this is a smart move because it brings him to $580 a month — $50 higher than the average pay for mechanicals with his experience. He knows that $530 is the average because he saw a survey of engineering salaries made by major employers in his town.

Cause and Effect

Root of the situation that permits a man like Smith to take six jobs in eight years is the shortage of engineers. But that shortage is breeding some side defects that promise to become as serious as the basic shortage. The scarcity is bringing unfortunate administrative habits in some managements, particularly in salary controls. It's accentuating prima donna qualities in some engineers who are taking undue advantage of being on the lucky side of a sellers' market.

There'll be no relief to the engineering shortage until at least 1960. Our fantastic technological growth demands new engineers at an unprecedented rate — 35,000 to 50,000 a year. The low birth rates of the 1930's result in a current slump in engineering enrollment — only about 24,000 engineers will graduate with bachelor degrees in 1956, compared with 22,600 in 1955 and 22,300 in 1954.

Interim Answer

What to do? Says E. L. Yates, director of college and university relations for General Motors Corp.: "We've got to wait out the shortage until the higher birth rates of the 1940's and the increasing attractions of engineering combine to bring us enough new engineers — which will probably be in the 1960's. In the meantime, we must provide the right climate that will hold and develop our technical men."

Are all companies providing the right climate? A glance at the want

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ads in any metropolitan newspaper will answer the question with "no." One observe estimates: "Any company that this year had turnover in its engineering personnel of 10 per cent or less is doing mighty well."

Reasons Why

Many had a much higher ratio, including one which lost 175 this year. So concerned was it with the problem that it surveyed 96 of those who quit to find out why. Of the 23 reasons given (see accompanying list), inadequate salary ranks only ninth. GM finds salary ranking near the bottom of the half dozen reasons listed most frequently for quitting.

That's surprising. To hear engineers talk, you would think salary is the big bugaboo. The complaint of a '51 graduate of Case Institute of Technology: "When I graduated four years ago, I got $298 a month. Today, I'm earning $463. Another Case man joined us this year from the class of 1955. He's getting $384. I'm not begrudging him his money, but I've had four years of experience there, and I'm getting only $79 a month more than he is."

Pattern

Case '51 knows so much about the starting salary of Case '55 because the competition for young graduates has made beginning scales fairly standard. For example, Case's director of placement, Arthur E. Bach, calculates that average starting salaries for men with bachelor degrees have jumped from $298 in 1951 to $400 in 1956 (see chart below.)

Industry is forced to pay that for starters, but it often doesn't make upward adjustments for its older engineers to keep the spread between the experienced and the inexperienced equal. The chart (on next page) of a Midwestern survey of engineering rates by age shows that, on the average, a man of 35 is making only $200 more a month than a man of 23.

Shortage of engineers will continue for many years in the future. . . . It is important to make the best use possible of those you have and the best way to do that is to keep them interested in a career with your company. . . . Some of these pointers may help

Complaint

No wonder engineers are restive, even though many a 35-year-old engineer is above average and is making far more than $585 a month. Many engineers (and some management men, too) criticize the present fad for engineering salary surveys. It tends to freeze the pay scale in the mythical "average" pattern. "Average" also tends to be on the low side. Although more and more companies are refusing to participate, enthusiasm for the survey is still strong. In one city, various companies in the area this year participated in at least five substantial checks.

Survey proponents argue: You've got to know what the competition is paying to hold engineers in these times. Opponents say: The survey puts too much emphasis on money, gives too many people the impression that money is the basic problem.

Management Problems

While money is important, other factors are even more common reasons why engineers quit, as indicated in the list on page E-6. The most important: Ineffective administration, talents not utilized, lack of recognition.

Administration

GM's Mr. Yates believes ineffective administration of engineers usually stems from poorly trained or picked supervisors and from a failure to make the engineer feel he's part of the company's whole operation. In this age of specialization, the engineer is the prime victim. So rapid has been technological advance that no one man can hope to work on all phases. He has to become a specialist. He often feels sidetracked.

GM attempts to dissipate the "sidetracked" feeling through monthly or bimonthly meetings with its engineering groups. Purpose: To tell engineers the overall problems of business. Some meetings on a specific problem are run by the engineers themselves. Occasionally an outside scientist comes in to talk. Tours of other plants are arranged. And the men are encouraged to join professional societies. GM generally does not pay the dues, nor do most other companies.

Good supervisors, of course, are a must. GM has a school for them. Other companies are sending supervisory candidates to college for special courses.

Talent

"I'm asked to do detail work that any good high school graduate with conventional courses in mechanical drawing could do," complains one engineering graduate. His complaint about poor utilization of talent is legitimate. Mr. Yates believes that industry should employ more technicians to do chores many graduate engineers have to do. His suggested ratio: Two or three technicians for every engineer.

In another phase of talent utilization, industry is also woefully weak. Of an estimated 800 companies in Detroit that employ engineers, only 50 have training courses. So unusual is it for a company to urge graduate work for its engineers that United Aircraft Company made headlines earlier this month when it persuaded Rensselaer Polytechnic Institute to set up an extension school at South Windsor, Connecticut, for the use of employees at United and other companies.

Many good training booklets and directives exist. One of the newest and

Engineers Starting Salaries Rise

1951	$298	1954	$373
1952	331	1955	384
1953	357	1956	400

Source: Case Institute of Technology, for men with bachelor degrees

Average Engineering Salaries by Age As Shown by One Survey

23	$385
24	395
25	400
26	420
27	450
28	475
29	490
30	510
31	530
32	545
33	560
34	575
35	585

best, "Detroit Industry Engineering Training Program," is available for $1 from Engineering Society of Detroit, 100 Farnsworth Avenue, Detroit 2, Michigan.

Recognition

A higher salary is the most practical form of recognition, but engineers indicate that they want other forms, too, and will often quit if they don't get them. A Chicago company nullified a threat to unionize its engineers when it granted them parking privileges, excused them from punching a time clock and permitted selected personnel to take time off to attend out-of-town professional society meetings.

But a more vital problem in recognition is what to do about the talented engineer who has no supervisory abilities. In some companies, a man can't get into the annual salary bracket of five figures unless he's a supervisor. GM has set up a nonsupervisory research associate who has salary, prestige and rank of a department head. The Cleveland Electric Illuminating Company created a system of specialists who are not supervisors but are related to them in salary and recognition.

In salary recognition, a company should review all engineers' salaries at least once a year, preferably every six months. A company like Reliance Electric & Engineering Company has an assistant chief engineer, C. R. Sutherland, one of whose major responsibilities is salary administration. He and many many other experts believe in creating a promotional series. A man may get promoted and get a salary boost, but he still may have the same job and title.

Enter, the Engineer

If some managements have to clean house, some engineers do, too. The most frequently voiced complaints: They're too slow to adapt to the realities of business life; they want the privileges of a profession but they shun its responsibilities, such as advanced education; they are overly concerned with money.

Adapting

Today, there are about four engineers per each 1000 people. There were two in 1940 and 1.3 in 1920. In 1920, they usually worked alone or in small groups. Today, they rarely work alone, but are usually part of a team effort. In 35 years, things have changed radically for engineers, probably more than for any other segment of our society. No wonder they're having adjustment problems.

Technological advances make some engineers think technical knowledge alone will take them to the top. Some technical schools have thought that, too. More and more are beginning to teach English and other liberal arts because they have discovered engineers need more than a slide rule to get along.

Professionalism

About 17,000 practice engineering in the Cleveland area, but only some 13,000 are members of any professional society, estimates Don Cornish, executive director of the Cleveland Engineering Society. How are those 4000 nonmembers keeping pace with technical developments, not to mention the society members who are not? Can a man call himself a professional if he doesn't take advanced training?

Says Gerry E. Morse, industrial relations vice president for Minneapolis-Honeywell Regulator Company: "The engineer cannot rely on simply absorbing technical developments without effort as a result of day-to-day exposure on the job."

Money

On the average, a young engineer starts out at about $25 a month higher than a liberal arts or business administration graduate. At the end of five years that gap has disappeared. At the end of ten, the business ad or liberal arts man may hold an edge over the engineer, although that's hard to prove. But some engineers believe you can. They see John Smith from Turpentine Tech earning $7000 a year while Bill Jones from Business U is pulling down $12,000 as a salesman. And Smith has to tell Jones the difference between a rotor and a stator!

Engineers are usually most bitter about salary when they have been out of college five to ten years. "That's the dangerous age when they're most apt to quit," says Mrs. John A. LeBedoff, director of placement for Western Reserve University.

Crucial

But the time to catch an engineer to prevent him from becoming an embittered 28 is in the first five years of professional development. That's what the Engineers' Council for Professional Development believes. It started a test program in Cincinnati in 1952. So successful was it that it's now being started in Detroit. And Minneapolis plans to try it.

The program offers an opportunity for employers, colleges and engineering societies to cooperate in making a contribution to young engineers. The program involves the preparation of booklets and other aids to help in six areas: Orientation and training in industry; continued education; integration into the community (because many young engineers are new to the area); how to join professional societies and how to qualify for professional certification; how to improve self-appraisal; and selected reading.

Mr. Yates sums up: "We can live through this engineering shortage if we better utilize our technical men and provide opportunities for them to improve themselves." ★ ★ ★

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Fourth of a Series

Communication:

How to Manage Sentences

Dr. Dennis Murphy

A BUSINESS WRITER should have two objectives constantly in mind:

1. **keeping his whole purpose clear and**
2. **making each sentence carry his meaning forward.**

A sentence is a word-group that carries a unit of communication. Each sentence we use should (a) form a complete unit in itself and at the same time (b) further the continuous flow of thought. We communicate with word-groups in a context, each group like a link in a chain — bound to what goes before as well as to what follows.

This article sets forth a few guiding principles that can help us make sentences go straight and clear. It also suggests how to improve them through careful revision. Every writer, however, will need to practice hard to master his craft.

Always Remember Mr. Reader

To get our communication job done accurately and effectively, we should think more about **what** we're saying than about **how** we're saying it. Both are important; but it's much better to write sense awkwardly, even poorly, than to write nonsense grammatically and gracefully. Good writing is like a straight line: It's the shortest distance between two points — writer and reader. And it should be good sense expressed sensibly.

Too much concern about **how** we express ourselves can lead to a self-conscious manner that's stiff or unnatural. Likewise, too much revising can knock all the spontaneity and life out of a sentence.

At the outset our reader will ask, *"What's this about?"*

First, he wants to get the **content.** Then while reading he'll notice the **form** — order, development, sequence, flow, tone — especially if the form is bad! When he finishes reading he may check the **effect** by asking himself whether he should ponder the message, go into action, or forget it.

Thus our purpose is clear: **make content and form work together to produce the desired effect on our reader.**

Getting Started

Knowing exactly what to say is half the battle. But how do we get those definite thoughts before we begin? Here are three tips:

1. **Turn the problem over in your mind**
2. **Talk it over with somebody else**
3. **Pencil some kind of rough outline**

If we just start writing, we're likely to wander, repeat, and get all balled up. When we do, even our best ideas sound half-baked. True, writing and rewriting help to clarify points, but we should think first to crystallize our ideas — before we ever put pencil to paper or start dictating.

Too often business writing falls into routine patterns. Actually, many of us get into the habit of wording our sentences a certain way until we can hardly word them any other way. Breaking the tiresome order of subject-verb-object is seldom done. To begin a sentence with conjunction, infinitive, phrase, or adverb is to commit sacrilege. And ending with a preposition is frowned on. So look what we're up against. Any machine or method used for 20 years in our fast-moving world is ready for replacement or change. But what about habit-thinking that keeps us in a rut for 20 years?

Use All Kinds of Sentences

Most of us may recall that sentences make a statement *(declarative)*, give a command *(imperative)*, ask a question *(interrogative)*, or exclaim about something *(exclamatory)*. About 99 per cent of all business sentences either make informative statements or give instructions, but we can add a sparkle by occasionally using a question or an exclamation. Then why not try it?

Many **loose** sentences ramble on,/ like this one,/ and lose their emphasis/ because they keep adding another idea/ and then another/ but could end/ many times/ before they finally do.

In contrast, a **periodic** sentence, like this one, is incomplete until the reader, held in suspense, reaches the very last word.

A **balanced** sentence poses one thought against another; it presents compactness with force. About 95 per cent of our

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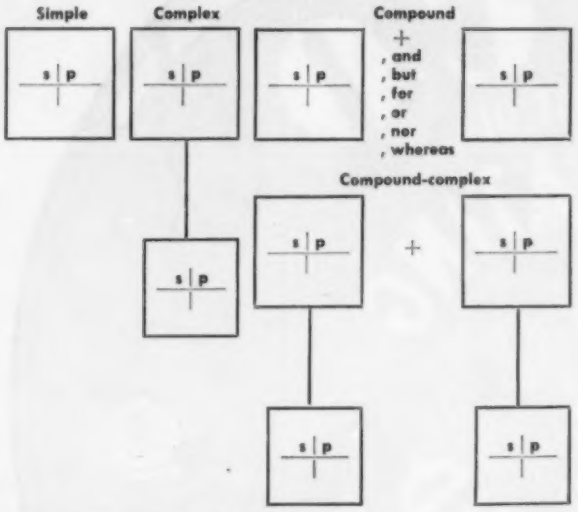
sentences are loose ones, but we should use all three types.

As to structure, a **simple** sentence has one subject and one predicate. A **complex** sentence has one main subject and predicate but also one or more dependent clauses. A **compound** sentence has two or more complete co-ordinate statements. If either or both of these has any dependent clauses, the result is a **compound-complex** sentence. Again, too many business sentences are compound-complex.



Brevity Is the Soul . . .

Keep your sentences short. They shouldn't average over 20 words. This doesn't mean that a 40-word sentence is poor if it is well knit, runs along smoothly, and is easily understood. You may need several unusually long sentences, but follow them with a short crisp one.

Too many choppy sentences, like riveters with their rat-a-tat-tat, grow monotonous. Too many long sentences, on the other hand, overloaded with details and exceptions and other ramifying if's or and's, bog any reader down and make him do a lot of backtracking to get the meaning. Vary the lengths. If you put your reader to sleep with a long one, wake him up with a short one. It carries punch at the end of a paragraph. It's like the cherry in a Manhattan!

Keep useless words out. "Be careful that you write accurately rather than much," said Erasmus. Especially when you're getting started, beware of prolixity. If the first page is waste motion, like a baseball pitcher's windup, throw it away. Dive right into your subject. Cut out repetition, and start a savings account with words. Notice these:

1. *In regard to the various and sundry reasons whereby Benjamin Franklin became not only eminent but also famous, there are at least several very good reasons. (26 words)*
   (Franklin became famous for several reasons.) (6 words)
2. *Actually he succeeded in landing the fish, otherwise known as a trout, in a way that was really very skillful. (20 words)*
   (He landed the trout skillfully.) (5 words)

Six Principles of Sentence Management

The following principles, sifted from dozens of "rules" on writing, are basic. If you master these six alone, you can correct 90 per cent of your sentence errors. Not bad, eh? Examine the faulty sentences; improved forms are in parentheses.

AID 1: *Make the Subject and Its Verb Agree*

1. Your **request** for prices of best-grade Bethlehem steel

in the 40-foot joints of 16-inch pipe **have been received.**
(We have received your request for prices of . . .)

Always use the active-voice verb instead of the passive, if you can.

2. The fantastic **paradox** of farm prices, on a toboggan slide while living costs soared skyward, **have ceased.** (Paradox have?)
3. The **supervisor,** as well as the foremen and group leaders, **are** here.

When you allow the subject to get widely separated from its verb, you flirt with trouble. Other nouns, singular or plural, come in between — and throw you off the track.

4. Tax **reductions** that went into effect last year **was** most helpful.
5. **Reports** that the crude oil would gel at low temperatures and then immediately liquefy when agitated in any manner **was investigated.**
6. The final **copies,** which go to his office for approval and distribution to each department and the field, **is** not ready.

Notice the use of **that** and **which** in the last three sentences. This might be a good place to point out their difference, a difference that seems to baffle 95 writers out of 100. **That** is restrictive and preferred in a clause that can't be omitted; **which** is non-restrictive and preferred in a clause that adds by-the-way information. **That** requires no comma before it; **which** does.

7. This is the machine **that** sold for $5,000.
8. This machine, **which** was manufactured in Canton, sold for $5,000.
9. Washington, **which** is our national capital, is growing rapidly.

You may use words in apposition rather than a which-cause.

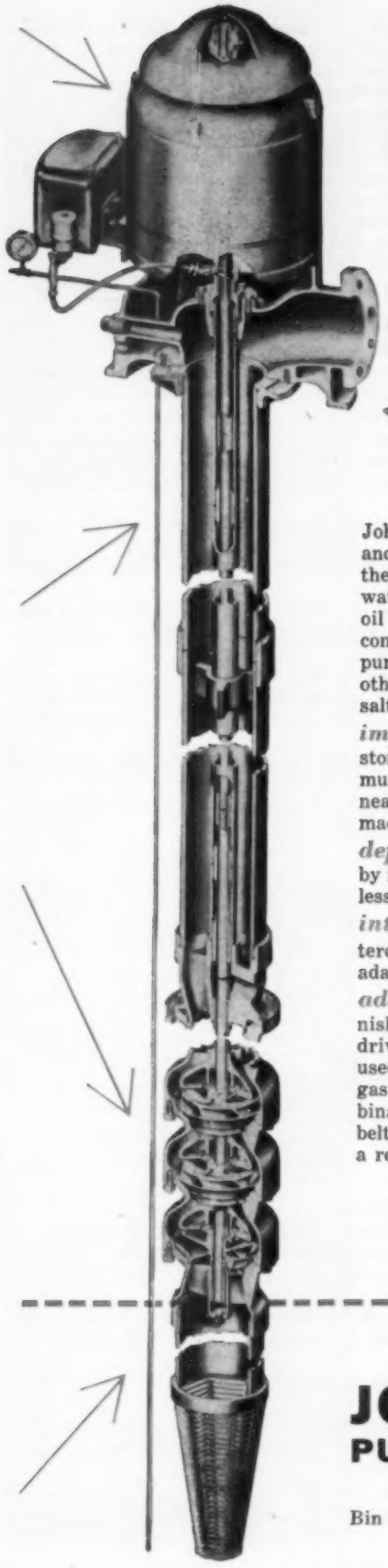
8. This machine, manufactured in Canton, sold for $5,000.
9. Washington, our national capital, is growing rapidly.

Like these better? Then you might try "which-hunting" among your own sentences.

AID 2: *Avoid Needless Shifts in Structure or Direction*

One common tendency is the unconscious change of construction midway in a sentence. Lincoln's famous advice, "Don't swap horses in the middle of a stream," is equally good here. Think through the entire sentence before you begin; if you can't hold that much in mind, maybe you're including too much. Better have three short clear units than one long jumbled one.

Once you launch into a sentence, hold to the same subject, tense, and point of view. If you set up one subject but tear it down to set up another and another, **you force your reader through a maze of psychological adjustments.** Why make him go through unnecessary mental processes?



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1. Any **man** who might accomplish this task, the whole **company** would consider him to be a genius, because that **job** is certainly not easy.
   (The man who could accomplish that tough job would be a genius to the whole company.)
2. This **heater** burns less oil, and at the same time the **salesman** says they can be cleaned easier, yet the **price** is relatively moderate.
   (The salesman says this heater burns less oil, is easily cleaned, and is moderately priced.)

Keeping the same direction in a sentence, too, makes reading a lot easier. Conjunctions like **therefore, consequently,** or **so (and so)** propel your idea forward; words like **nevertheless, but** or **yet** throw your idea into reverse and pull it backward. Try not to change your direction more than once.

3. Operations were delayed for a short time, **but** we knew our power would be limited, **for** we had anticipated this breakdown, **but** operations were disrupted only 12 hours.
   (Operations were delayed a short time and disrupted only 12 hours, because we anticipated this breakdown and knew our power would be limited.)
4. Playing football teaches a young man how to be alert, not to shirk their responsibilities, and they learn what to do in an emergency.
   (Playing football teaches a young man to be alert, self-reliant, and resourceful.)

Keeping a parallel structure makes easy reading. When you have several relatively parallel ideas, make them all go the same way. That is, put them all in the same construction—infinitives, gerunds (verbal nouns), phrases, clauses, participles, or what-have you. In sentence 4 the ideas of alertness, self-reliance, and resourcefulness go every which way. That slows up any reader.

AID 3: *Watch Every Pronoun's Reference and Agreement*

No word causes more trouble that the little pronoun. Because it always **refers** to some noun, it must always **agree** with that noun.

Wrong Reference:

1. Everybody should mind their own business if they wish to succeed.
   (Everybody should mind his own business if he wishes to succeed.)

Mixed Reference:

2. You'd better see Evans than Jones because he's busy right now.
   (You'd better see Evans because Jones is busy right now.)

No Reference:

3. He didn't hear the whistle, which was due to his deafness.
   (He didn't hear the whistle because of his deafness.)

Loose Reference:

4. The bottle must be kept clean for the baby; so, after feeding it, sterilize it with boiling hot water. *(Wow, poor kid!)*
   (The baby's bottle must be sterilized after each feeding.)

Ambiguous Reference:

5. The employer told the employee that he would ruin his reputation if he didn't rewrite his letter.
   (Better use a direct quotation here: The employer said to the employee, "You'll ruin my reputation if you don't rewrite . . .")

Sometimes you can manage this kind of sentence by putting one noun in the singular, the other in the plural.

The employer told the employees that they would ruin his reputation if they didn't rewrite his letter.

Can you tell whether each italicized pronoun below is in the right case? Mark each sentence R or W (Right or Wrong).

1. Nobody but Bill and *me* was left on the job.
2. The winner was thought to be *he*.
3. They believe the culprits to be *us*.
4. I don't recall *his* going into the office.
5. He is the man *who* we believe did it.
6. We can drill for oil as well as *them*.
7. We'll cooperate with *whoever* you choose.
8. Give it to *whomever* fills out the blank.
9. The boss invited my wife and *I* to attend.
10. Between you and *I*, *whom* do you think broke the machine?

(Answers: the first five are right; the last five are wrong.)

AID 4: *Look Out For Dangling Modifiers and Misplaced Words*

No sentence sounds sillier than one with dangling modifiers. Both participles and infinitives are verbal forms that modify a noun. The trick here is to make sure that we use the **right** noun for each to modify. We may as well have some fun while we learn from these ludicrous examples:

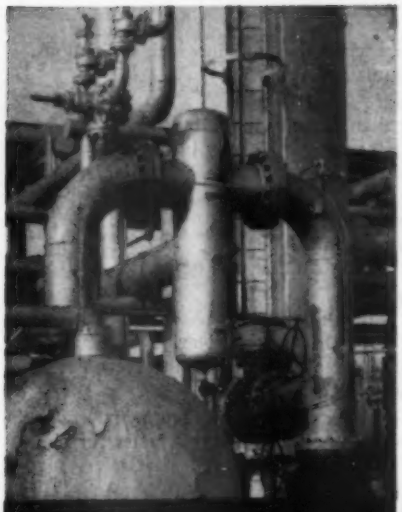
1. Enclosed, please find . . . **(You** *is the understood subject.)*
   Attached, please find . . . (Are **you** *attached or unattached?*)
   Under separate cover, please find . . . (*Twin beds, you see.*)
2. After trying in vain to reach you by telephone, this letter will notify you of your appointment. *(Who was trying in vain?)*
3. Referring to your letter of March 17, the cost is itemized below. (*Is* **cost** *doing the referring? Referring to your letter of March 17, we have itemized the cost below.*)
4. To balance our figures, fuel oil in the sales column is included.
   (To balance our figures, we include fuel oil in the sales column.)

More dangling participles:

5. When thoroughly stewed, you will like these prunes.
   (When thoroughly stewed, these prunes are delicious. Or maybe, when thoroughly stewed, you will like anything!)
6. Clogged up with coffee grounds and frozen solid, the plumber was called in to repair the drain pipe. *(Poor plumber!)*
7. After bolting my sandwich, the plane took off. *(Hungry plane!)*
8. Doing 60 mph with the cut-out open, a Jersey cow collided with his Buick at Fourth and Main, causing a great spill. *(I'll bet.)*

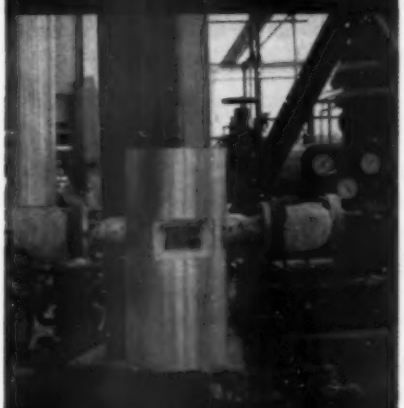
Dangling phrases:

9. After a brisk swim, hamburgers and beer always hit the spot.



A Peerless Line Separator is shown above removing entrainment from a refinery reboiler.

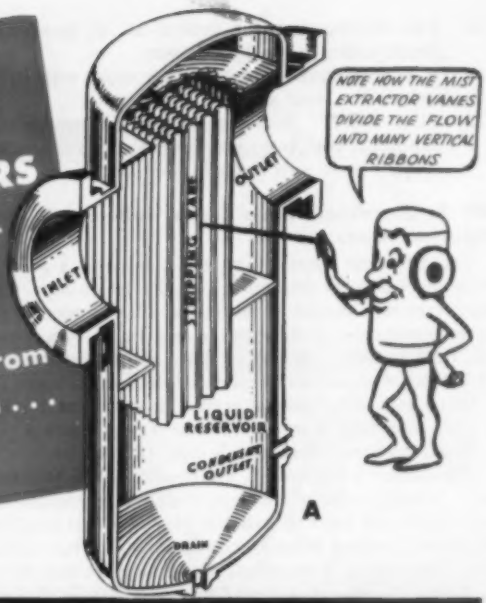
Peerless Line Separators are doing an effective job of mist extraction at this Kentucky Petrochemical Plant.

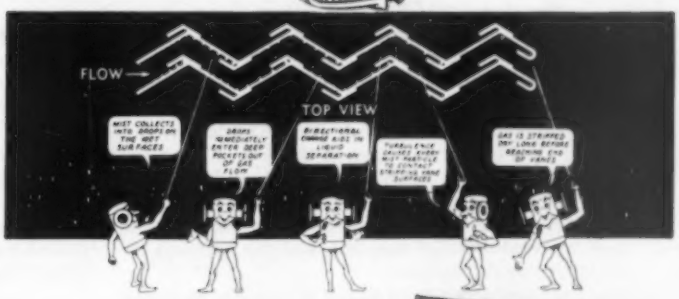


This is an insulated Peerless Steam Separator on a turbine driving an airblower.

PEERLESS LINE SEPARATORS

Outstanding for the efficient extraction of liquid mist from gas or steam . . .





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Thousands of installations throughout the Refining and Chemical industry have proven the Peerless Line Separator principle to be one of the most outstanding methods available for the extraction of liquid from gas, steam or air.

Drawing A above shows the arrangement of the vanes in the Separator. Drawing B is an illustration of the Peerless principle.

The mist extractor combines the forces of impingement, centrifugal motion and surface tension to obtain its high efficiency. The path of the gas, etc., through the unit is constantly bending, causing semi-violent turbulence and rolling of the gas against the walls of the vane. Impingement and centrifugal force combine to contact the droplets with the vanes, where they coalesce, and surface tension then causes them to cling to the vanes' surfaces. Gravity and the impact of the gas stream then drives the droplets into the pockets where they roll down the vanes and out of the gas stream.

Through the Peerless method of mist extraction, the gas is stripped dry long before reaching the end of the vanes.

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REPRESENTATIVES IN ALL PRINCIPAL CITIES

10. The marshal keeps a record of all fires started by pyromaniacs in his desk drawer.
11. A blonde secretary entered the room with the largest freckles I've ever seen.
12. FOR RENT: Bedroom by refined lady with sunny exposure for two businessmen recently plastered. *(Supply your own remarks here.)*

AID 5: *Coordinate Equal Ideas; Subordinate Less Important Ones*

This principle sounds easy, but it requires a good deal of weighing values to determine logical relationships. The most important idea should be put in the most important position. in the sentence — that is, first or last. Parenthetical elements, like **furthermore** or **in fact** or **if we are not mistaken,** should be tucked in somewhere in the middle. Notice these:

Of course, this statement is true. *(Is* **of course** *a transition?)*
This statement is true, of course. *(weak ending)*
This statement, of course, is true. *(Best)*

The longer a sentence is, the harder it is to evaluate ideas in it. And any isolated sentence is almost impossible to evaluate because we can't tell what to play up, what to play down. Without knowing what's gone before or what follows, we don't know what is intended. But let's do the best we can.

Faulty coordination (all ideas are equal):

1. I have a dog, and he's a setter, and he's black and white, and I found him dead when I came home yesterday.
   (I found my black-and-white setter dead when I came home yesterday.)
   Dead, the all-important word, is still buried in the middle. Let's try for emphasis at the end.
   (When I came home yesterday, I found my black-and-white setter — dead.)
2. The next step is the laying of the foundation, and it must be constructed of concrete, and our men can do the mixing of the concrete.
   (The foundation must next be laid of concrete, properly mixed by our men.)

Faulty subordination (major idea in minor position):

3. We were returning in the truck when the explosion and fire occured.

Main idea	Subordinate idea
(The explosion and fire occurred when we were returning in the truck.)	

Main clause	Subordinate clause

AID 6: *Beware of Faulty Comparisons*

Comparison and contrast are two vivid and useful devices in writing. Managing them is easy when the thinking is clear, but they cause trouble when they are illogical, ambiguous, incomplete, or ungrammatical.

Illogical comparison:
Cleveland is larger than any city in Ohio.
(Cleveland is larger than any other city in Ohio.)
Since Cleveland is a city in Ohio, how can it be larger than itself?
His salary was lower than a typist.
(His salary was lower than a typist's.
Or, His salary was lower than that of a typist.)

Ambiguous comparison:
Is Chicago nearer New Orleans than New York?
(Is Chicago nearer New Orleans than New York is?
Or, Is Chicago nearer to New Orleans than to New York?)

Incomplete comparison:
Try Westinghouse — it's safer. *(Safer than what?)*
He ordered wine because he thought it was better for him. *(Than what?)*

Ungrammatical comparison:
Production in 1955 was as large, if not larger, than in 1954.
(Production in 1955 was as large as in 1954, if not larger.
Or, Production in 1955 was as large as, if not larger than, in 1954.)

Paragraphs Are Built

The first sentence in a paragraph of business writing usually carries the most important idea. Called the topic sentence, it resembles the hub of a wheel or the central core of a modern building. Like spokes of the wheel or conduits of the building, other sentences lead from it, refer to it, and develop it. These related parts give the whole paragraph a unity. Transitional elements, of course, give it coherence. And by unloading the most important idea first, we help the hurried businessman to skim and get the meaning quickly.

Here's a picture of the preceding paragraph:

topic sentence
developing sentences

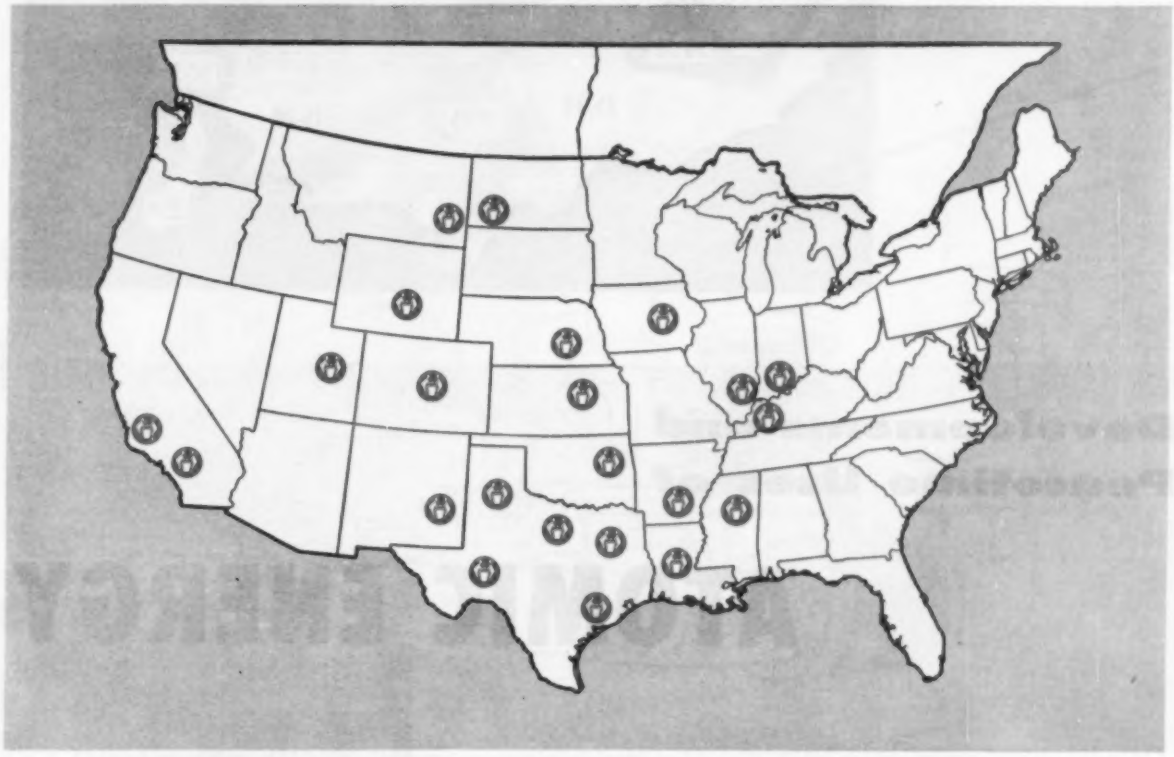
Keep your paragraphs short. The 90-word paragraph above contains six sentences whose average length is 15 words. That insures easy reading. Most business material, however, is more difficult than this. But that's all the more reason for breaking it up into short digestible units. So, try to hold each paragraph under 100 words; if they run from 200 to 400 words each, they're too hard for the average reader to struggle with. Remember, he reads on the run and needs to understand in one reading.

Don't Worry About Style

Yes, you want your sentences to have correct grammar, structure, punctuation, and spelling. But style never depends on correctness. It depends on hitting the right tone, the right frame of mind. So become aware of your tone — your attitude toward the reader, your feeling about the subject, and the spirit you want your words to communicate. As a man thinketh, so is he.

Nothing communicates your nature more accurately than your language. It always reflects you like a mirror — as stiffly cold, warm-hearted, arrogant, friendly, confused, accurate, facetious, serious, indifferent, helpful, or whatever you are. Don't imitate anybody else, either, unless you want to show up as a parrot or a parodist. Be yourself. And your honest expression will create its own style, the style exactly right for you! ★ ★ ★

Financing from the **FIRST** *in Dallas goes where you go!*



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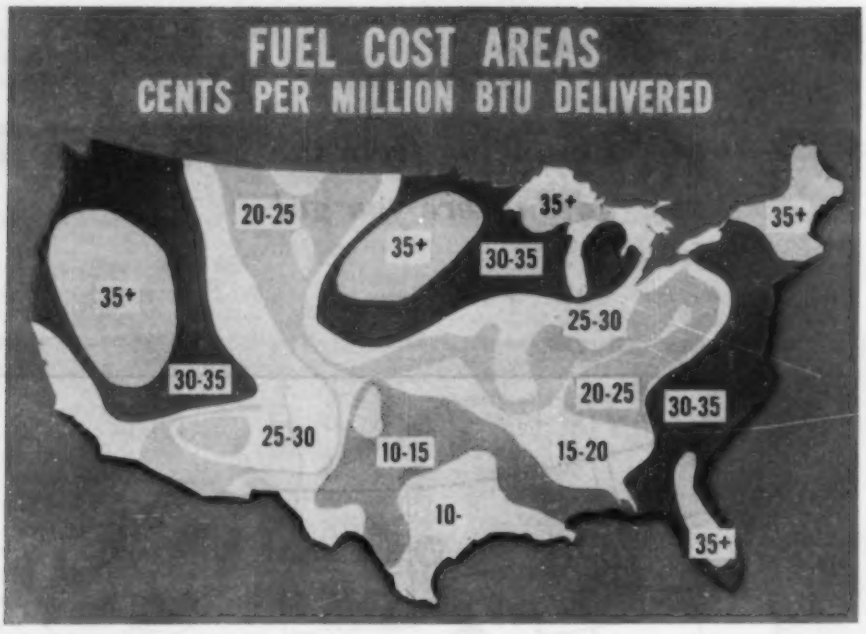

Developments and Peacetime Uses of ATOMIC ENERGY

The Author

Mardis C. Compton is manager of sales, atomic power equipment department, atomic products division of General Electric Company. He was formerly supervisor of sales for the company's large steam turbine department and former manager of product planning for the small steam turbine department. From 1948 to 1952, he was district turbine specialist at Dallas, Texas. A graduate of Purdue University, Compton began work with General Electric in 1937 on the test program and entered turbine sales in 1939.

I'D like you all to close your eyes for a moment and try to visualize the number I'm going to read off. It's a big one, so try to keep up by adding zeros as I call them out. Ready?

1,000,000,000,000

That's a trillion. A *million* million.

If you add 40 billion more to it, you have the predicted 1964 kilowatt-hour power production in the United States. It's a staggering figure, to be sure, but actually it represents a conservative prediction of the energy needs of our nation 10 years from now. The problem facing our nation today is to provide the power for these enormous demands. Is atomic energy the answer to this problem?

Any discussion of atomic energy should take into consideration the importance of energy itself, without particular reference to the atom. Many people are carried away by the thought of atomic energy, with the main emphasis on "atomic" because it is new and dramatic, and only a glancing thought, if any, for the basic idea of energy. American industry, however, is not investing money and research in the development of peacetime atomic power simply because it is a dramatic and novel way of producing power.

Atomic energy is important only because *all* energy is important.

The next question is: Where does atomic energy fit into the economic structure as we know it today, and as we project it for the future?

Let us start with the fundamentals. As you know, energy comes from the sun. Some arrived today and is giving us warmth and light. Some arrived within the year and furnishes us with food. Much arrived in our lifetime and

†Presented at 27th annual conference, Petroleum Electric Power Association, Dallas, Texas, September 26-28, 1955.

He skipped the same 2 valves again today

Both are still in adjustment. Still no leaks, not even at the shank! Both are OIC plug valves. If he's curious enough to dismantle one, he'll see the OIC gland and O-ring construction that saves him time and cussing. It's different from other plug valves he's seen.

Three efficient seals prevent shank leakage on OIC plug valves. Concentric grooves machined into the gland liner form a "labyrinth" seal. The liner also retains an O-ring in contact with the plug's top face for a second positive seal. And resilient packing between gland and gland liner forms the third seal.

But the maintenance man measures design by *results*. OIC plug valves get his O. K. because they stay in adjustment a long time without leakage. However, if *you* are interested in the exclusive gland design and construction of these OIC plug valves, write for specification literature.

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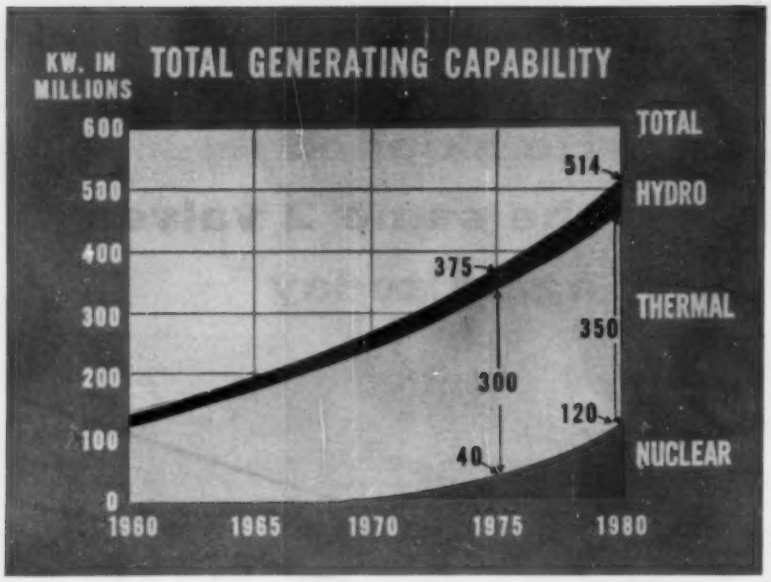


contributes to our shelter and other construction. Much more arrived many thousands of years ago and built up the supply of fossil fuels from which we obtain vast quantities of heat and electric energy.

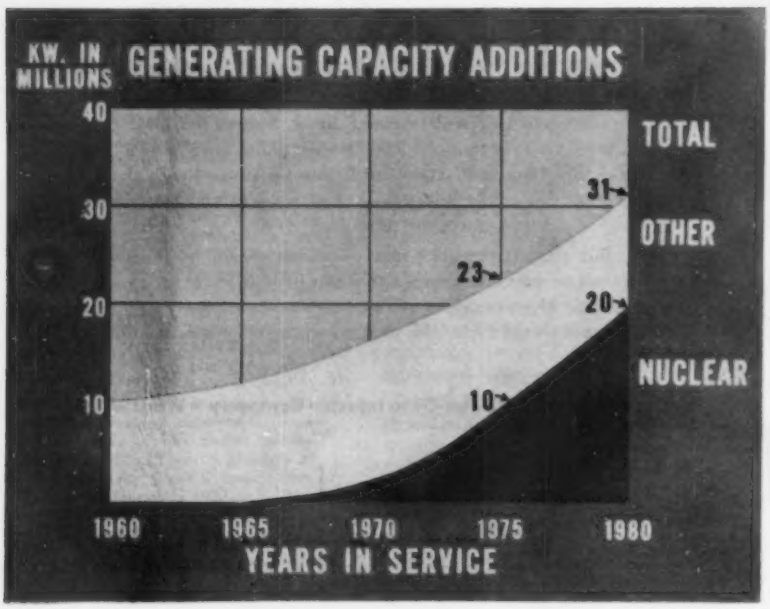
The importance of this energy is obvious. It is no accident that the United States with only 7 per cent of the world's population produces 50 per cent of the world's manufactured goods. More than any other factor, abundant energy is the cornerstone of our productivity and of our standard of living. Stuart Chase has said truthfully I think that "nowhere on the horizon is there a saturation point for power. Its future is limitless. It not only marches to ever greater quantitative output, but also transforms the entire economic structure as it goes."

It may be argued that we have been able to harness and use this freely available energy because we live under a democratic free enterprise system. Whatever the reason, the facts are that we *make*, and, therefore, *have* more goods and more leisure than any other nation. A great part comes from the simple fact that in our homes, and in our factories, and in our travel, abundant energy is available and freely used to multiply our strengths.

The United States and a considerable portion of the Free World have been living high on the accumulated capital energy in the tremendous reserves of coal, oil and gas. Rates of extraction of these non-renewable fossil fuels have been unbelievable. The U. S. has used them freely to establish the highest standard of living in the world. Furthermore, we have reached the point where our standard of living is regarded not as an achieved level, but only as a directional signal — always pointed upward.

If "low cost" energy is going to determine our very economic health, then conventional fuels will have to carry more load than reports indicate they are capable of handling. The projected power demands of the future, in the main, can be supported only by some new source of energy. We feel atomic energy represents this *new source of power*.

Here's how these energy sources compare: ¼ cu in. of uranium can produce as much energy as 6,000,000 cu ft of gas, 7000 cu ft of oil, and 5000 cu ft of coal.



Energy Demand

Why do we keep thinking in terms of growing demand for energy? What are some of the forces that will create a continuation of this seemingly insatiable demand for power? First of all, world population is growing at a tremendous rate.

Available information suggests that an estimate of 6 to 8 billion world population in the year 2050 is a conservative figure. Six billion is almost two and one-half times the present world population.

Secondly, the standard of living of all countries is on the rise. By that, I mean not necessarily the actual standard, but the ideal or *desired* level of living as a projected goal is far above the mere subsistence or marginal-subsistence level that exists so prevalently today.

The West's answer to this situation is increased production, based on a wider utilization of energy — an expansion of goods and markets. Russia's answer, up to now, has been the enforcement of a socio-political system, which consists largely of rechanneling existing goods and services. We have seen this system lead to a constriction of economies and the resultant dissatisfaction of subjugated peoples. However, Russia, too, is engaged in the application of atomic energy to power generation. One of our main goals now should be to see to it that Communism plus atomic power do not convert the world where Communism alone has failed.

10-Year Estimates

This growth in population and general rise in the living standards will

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Wherever bronze globe valves are used, LQ600 has been setting and breaking new performance records . . . in petroleum, paper, chemical and in power and industrial installations generally. *There has not been one reported case of leakage or failure* of an LQ600 Valve—even on "killer" services where the valves LQ600 replaced were lasting only two weeks to two months.

There's a surer way to low-cost efficiency than replacing or regrinding seats and discs and repairing leaky valves. *Brinalloy* seats and discs in LQ600 Valves do not need replacing or regrinding.*

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have a meteoric effect on the economy of the United States. Here are some of the figures from 10-year estimates for our economic picture:

The Gross National Product is expected to reach 490 billion dollars — 37 per cent increase over last year's 357 billions.

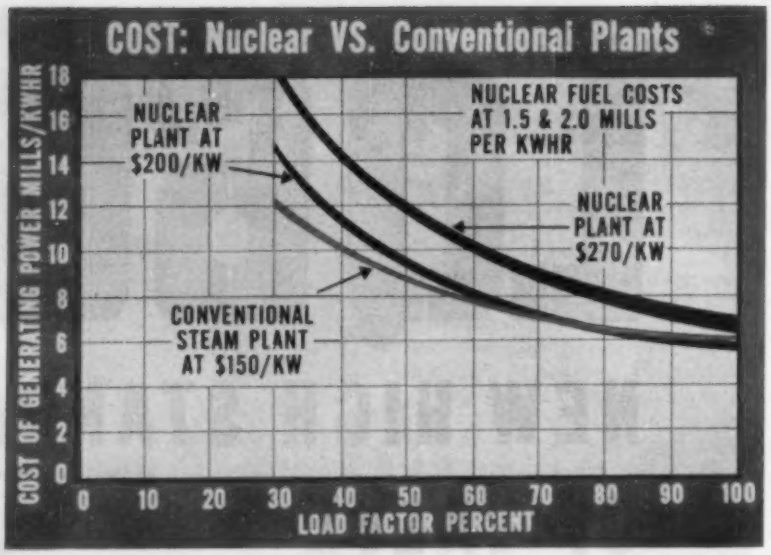
This prediction is based primarily on the Bureau of Census' estimate that, in that period, our population will rise from its present 165,000,000 to 192,000,000 — a 14 per cent increase.

The Federal Reserve Board's Index of Industrial Production will reach a record of 195 — a 43 per cent rise.

Our national purchasing power will go up proportionately; employment will rise, and we will have a record 350 billion dollars of disposable income — a 42 per cent jump from this year's 248 billions.

Translated into energy-power terms, this vast economic structure will be sustained by the 1 trillion, 40 billion kilowatt hours of electricity — a 150 per cent increase over the 1954 rate of electrical consumption.

It is to help meet this enormous growing demand for more and more power that the atomic energy plans of American industry, are geared. I believe industry is reasonably well equipped to cope with this problem and, as an example, I would like to just briefly review for you General Electric's experience in this new and fascinating field.



Atomic Projects

During World War II, the Government took over our atomic energy activities. For the duration of the war, we supplied men, machinery, equipment and technical know-how and assistance to Manhattan District projects at Oak Ridge and Hanford. At the close of World War II, the Manhattan District asked General Electric to take over the operation of its Hanford Works at Richland, Washington, which we did in 1946.

In the 9 years that we have operated Hanford, the production of plutonium has grown tremendously, while the cost of producing it has been reduced unbelievably.

Also in 1946, and across the continent from Hanford, General Electric constructed the Knolls Atomic Power Laboratory in Schenectady for the Atomic Energy Commission. At KAPL, as we know the laboratory, we have built the first sodium-cooled power reactor. It is in the prototype submarine hull in the big sphere at West Milton near Schenectady. This submarine intermediate reactor (SIR) has operated in a most satisfactory manner, and a duplicate was placed in the USS "Sea Wolf," which was launched in July at Groton, Connecticut.

The SAR Project, standing for submarine advanced reactor, is also in progress, at the Knolls Atomic Power Laboratory and will power a successor to the "Sea Wolf" that will have even greater power potential.

In 1951 we established our Aircraft Nuclear Propulsion Department at Evendale, Ohio, near Cincinnati. There, research and development is going forward on the nuclear power plant for a military aircraft. This operation also includes some test facilities at the National Reactor Testing Station near Idaho Falls, Idaho. The tightest veil of secrecy surrounds the project. From what we have learned in our 4 years' experience with aircraft nuclear propulsion, we are practically certain that atomic-powered military aircraft can be produced and will have possibilities well worth their cost.

Thus, when we established our atomic power study in 1953 to work on the problems of generating electricity from the heat of atomic fission, we had 14 years of atomic energy background, including the operation of Hanford's tremendous graphite-moderated reactors, work on reactor power plants for submarines, and work on a reactor power plant for aircraft. We brought this experience in research, engineering and manufacturing skill to bear on the problem of power reactors for generating electricity from nuclear energy.

In January, General Electric isolated the first isotope occurring in nature to be found in 6 years. This was the radioactive isotope of tantalum, TA-180. Before this discovery, tantalum, a metal sometimes used in place of platinum, was believed to have only one isotope, with a mass number of 181. The new isotope was identified by use of a new mass spectrometer, 100 times more sensitive than any similar instrument then being used to seek out isotopes. This new instrument was designed at the Knolls Atomic Power Laboratory a year ago, and, when we uncovered this new radioactive isotope of tantalum, was being used in a systematic search of the elements carried on as a means of understanding the nuclear structure of many metals.

On July 18, the first commercially distributed electricity made available for use in homes, industries and farms of the free world was generated from atomic power at West Milton, New York. This power was distributed over the lines of the Niagara-Mohawk Power Company. The 10,000-kw generating equipment and plant was installed and is being operated at no cost to the Government by General Electric. Steam is obtained from the prototype submarine intermediate reactor inside the sphere, and income from the sale of electricity will go directly to the Government.

While General Electric is not in the power-producing business, it installed and operated this equipment so that it would be possible to demonstrate the peacetime use of atomic power in the free world in the earliest possible time. This was fostered by a deep belief on the part of the company that the generation of power for utility use from a nuclear source is extremely important to our national interests.

The third new thing was announced by the government of Canada, that the Canadian General Electric Company will design and build Canada's first

MAINSTAYS of PRODUCTION

wherever the spread runs!

In terrain like this, east of Plevna, Montana, production averaged three miles a day. O. R. Burden Construction Corp., Tulsa, Oklahoma, used an equipment line-up that was predominantly Caterpillar for money-making performance.

Along with these two CAT* MD6 Pipelayers on this spread east of Plevna, Montana, the O. R. Burden Construction Corp. relied heavily on other Caterpillar equipment for profitable production. Included in its line-up here were the following big yellow units: three D8 Tractors, four D7 Tractors, one MD7 Pipelayer, two D13000 Engines in Cleveland ditchers and a No. 12 Motor Grader.

You'll find that concentrating on Caterpillar equipment pays off *three* ways:

1 Every unit, from pipelayer to motor grader, is ruggedly constructed to stand up under the beating of pipeline construction. The MD6, for instance, has an exclusive oil-type clutch that seldom requires adjustment and lasts much longer than ordinary clutches. And its bellows sealed track rollers keep mud and dust out for longer life. These, and other Caterpillar-developed features, enable it to do *more* work at *lower* cost with *less* down time on any job.

2 Familiarity with Caterpillar's simply designed engines enables your mechanics and grease crews to handle maintenance routine with a minimum of time.

3 The network of Caterpillar Dealers makes it easy for you to handle your replacement parts problems wherever you are. Here's word from Burden's Spread Superintendent C. M. Hoffman about this: "Wherever our spread runs, we find Caterpillar Dealer service ready and willing to keep our Cat equipment in top operating condition."

What's more, you'll find the latest developments in pipeline equipment *first* at your Caterpillar Dealer. One example: the all-new 190 HP No. 583 Pipelayer —the first complete pipelaying unit, with a lifting capacity of 130,000 pounds maximum. For complete information on the rugged yellow line, see him today.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

USE CAT EQUIPMENT FOR MONEY-MAKING PRODUCTION

atomic electric plant. This will be a $15,000,000 experimental nuclear power station, producing 20,000 kw of electricity, on the Ottawa River near Canada's Chalk River Nuclear Research Plant. Ground will probably be broken this year, with completion of the plant scheduled for 1958. It is believed that this demonstration power reactor will be based in the main on the heavy water technology.

Evaluation of Energies

It might be interesting from your standpoint to note right here that continuing studies on atomic energy are of a great deal of value in pointing out the limitations of nuclear power in certain fields as well as the advantages in others. Paradoxically enough, the widespread use of atomic power will increase the value of conventional fuels by delineating the areas where they will have to carry future loads because of the impracticability of using the atom in such applications.

For example, in the field of transportation, the start of an atomic navy has been made, and it is practically certain that atomic-powered military aircraft can be produced and will have possibilities well worth their cost. Frankly, however, I see few other transportation possibilities. Atomic-powered merchant vessels may come, but I believe they must be based on some new concept or need in ocean transportation. I doubt if I will ever see practical, economically useful locomotives, automobiles, or trucks using atomic energy of the type we know today. Hence, if this is true (with the exception of naval ships and some military aircraft), chemical fuels must continue to supply our ever-increasing needs for transportation.

Thus, the present reserves of fossil fuels, far from becoming obsolete, will increase in value as the growing development of atomic power gradually points out the natural limitations of nuclear energy and underlines those areas that will be competing for the existing stocks of chemical fuels.

Although we can be sure that there will be some application of nuclear energy for transportation, for heating and in chemical processing, yet there is little question but that the greatest presently foreseeable application will be in the production of electric power. Our forecast on the percentage of new generating plants added to utility systems in the United States that will be nuclear-fueled starts out with a low figure of around 2 per cent in 1965. We estimate that there will be substantial activity after that, resulting in 14 per cent of the plants going in service in 1970 being nuclear. Our analysis indicates that once nuclear plants become competitive, they will expand rather rapidly — increasing to 44 per cent by 1980.

Nuclear Costs

One of the factors that will affect this rate of growth will be the cost of the nuclear plant in relation to the conventional plant. At the present time, and probably until 1960, the cost of building an atomic power-generating plant of the boiling reactor type is estimated at somewhere between $200 and $270 per kilowatt, while the cost of building a conventionally fueled steam plant of the same size would be about $150 to $175 per kilowatt. Many individual items in each plant cost about the same, since certain apparatus is constant, no matter what energy source is used. But some of the components for the nuclear plant are very expensive compared with their equivalents in a conventional plant. For example, the reactor cost $45/kw, while the steam boiler costs $28/kw. The feedwater system is twice as expensive for a nuclear plant as it is for a conventional steam plant because of the very high purity required of the process water.

There are several things, however, that could reduce these differences and produce a downward cost trend. Among these are:

1. Using the maximum size of reactor can achieve unit economies and greatly reduce overhead costs.

2. Development costs — initially high for a few units — can be materially reduced and should be distributed over a larger number of reactor projects.

3. Higher quantity production will reduce the cost of components.

4. Other improvements in fuel technology, waste handling, testing procedures, and other safeguards will also help to bring the initially higher costs within competitive range of conventional plants shortly. By 1980, the cost of a nuclear plant is expected to decrease to somewhat in the neighborhood of $145 to $165/kw.

This cost differential in favor of existing conventional power plants is not expected, however, to greatly hinder the beginning of our atomic power program because of the future advantages that will accrue to people who are willing to pioneer in the field.

The outlook is bright for the increased installation of nuclear power plants over the next 20 years and, if this seems like a long period of time, remember that we are dealing with large, long-range solutions to sweeping long-range problems. And the full benefits to be derived from the utilization of this new source of energy will be tremendous enough to affect many facets of our lives.

Coupled with the direct power application, a great deal of consideration should be given to the subsidiary benefits of the atom. These are mainly in the field of industry, research, agriculture and medicine.

I cannot supply you with a comprehensive evaluation of the things that are happening in this area. However, let me enumerate just a few!

In the Petroleum Industry. Radioactivity tracers are used to keep track of different products in pipe lines, and Standard Oil of New Jersey is working on a method of using atomic energy to improve refining processes.

In Food Preservation. Within the past year, much has been done in the irradiation of meats and fruits and other foods with gamma rays, and it has been found possible to store some foods for months, after treatment, at room temperature without spoilage.

In Medicine. Much work is being done here in the use of radioactive tracers introduced into a patient's system, to be tracked with scintillation counters —instruments something like a Geiger counter — as they are absorbed or passed off by the system. Another highly important application of atomic energy in medicine is in the fight against cancer.

In Chemistry. Fascinating work is being done these days in the irradiation of plastics. It has been found that certain plastic materials, when exposed to gamma radiation, can be subjected to considerable heat without melting or losing their shape. Specific drugs, for instance, can be packaged and sterilized right in their plastic containers.

In Agriculture. Here, plant growth is being studied through the use of radioactive tracers that, added to fertilizer or soil, can be tracked by instruments.

I have only been able to trace the broad outlines of the atomic power field. We recognize that we must think in broad terms and implement large plans if we are to realize the full potentialities of this new force. I am convinced that applications of atomic energy in our future are almost limitless. ★ ★ ★

BEAIRD-INGERSOLL-RAND
Packaged Compressor Plant

Lowest Cost Per Horsepower Installed

Expanding Station Uses . . .

PACKAGED COMPRESSORS IN 5 YEAR PROGRAM

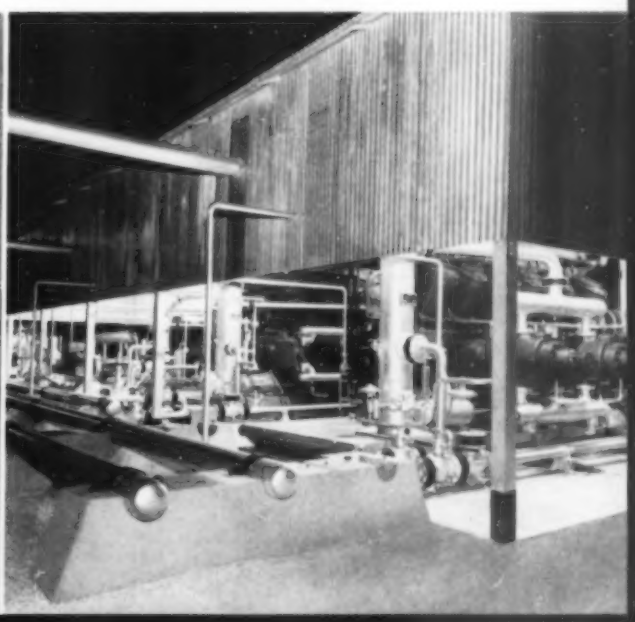
R. E. SMITH CARTHAGE FIELD COMPRESSOR STATION—equipped with three Beaird-Ingersoll-Rand gas engine driven packaged compressor plants, Young radiators and all necessary controls. Beaird packaged compressor plants are available in a range of sizes from 110 to 660 h.p.

R. E. SMITH planned his Carthage Field compressor station for economical step-by-step expansion by utilizing packaged compressors. Now boosting gas from 200 psig to 1,300 psig at the rate of 10 mmcfd, the station has grown from a single 220 h.p. Beaird-Ingersoll-Rand Compressor Plant to three units with a total of 1320 h.p. all supplied by Beaird to meet increasing needs.

Originally designed with piping and connections for additional units, the station added the second compressor, a 440 h.p. Beaird 8SVG, when new wells were tied into the station. The third, a 660 h.p. Beaird 12SVG, was installed when wellhead pressures dropped and two-stage compression became necessary. At present only the largest and one small unit are needed, but as the pressures drop still further all three will be used to follow the suction on down through final production stages.

Fully automatic and designed for unattended operation, the station has required no increase in personnel to handle the added units.

Let us show you how packaged compressors can provide the most economical means of enlarging your present compressor station.



THE J. B. BEAIRD COMPANY, INC.
Shreveport, Louisiana

BEAIRD

MACHINING • MANUFACTURING • STEEL WAREHOUSE

PACKAGED COMPRESSOR PLANTS

CAST STEEL FITTINGS

PRESSURE BULK STORAGE

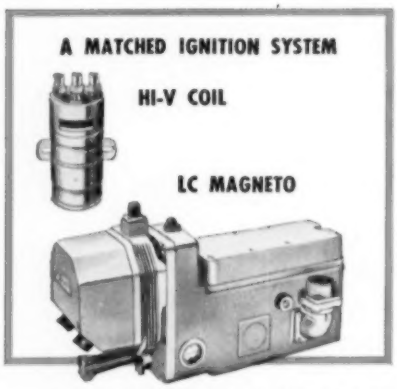
ANHYDROUS AMMONIA EQUIPMENT

LP-GAS SYSTEMS

Look at All You Get in the New Bendix LC IGNITION!

1. Long service life
2. Simplified maintenance
3. Longer spark plug life
4. No unscheduled ignition shutdowns
5. Positive spark timing
6. High voltage output
7. Matched ignition system
8. Single or dual ignition
9. Flame proof
10. Low maintenance costs
11. For engines of 6 through 16 cylinders

Designed Specifically for the Petroleum Industry



Just check these outstanding exclusive features and you will know why the Bendix* LC Magneto has been engineered to meet the exacting requirements of the modern high-compression gas engines used so widely throughout the petroleum industry.

As the Bendix LC is a completely new type of magneto, it incorporates the latest development in material, engineering, design and production techniques. The result is a matched ignition system—LC Magneto plus Bendix Hi-V Transformer coils—that delivers more than ample voltage with greatly reduced maintenance costs.

For engines of 6 to 16 cylinders where top performance is a must, the new Bendix LC Magneto is the logical choice.

Complete descriptive folder is available on request.

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Bendix
SCINTILLA DIVISION

Bendix
AVIATION CORPORATION

PUNCH CARD SYSTEM

For the Petroleum Industry

Alan R. Krull

ANY letter, bibliographical note, comment, idea, report, reprint, etc., which is to be put into a conventional filing system (with the intention of efficient retrieval at some later date) can usually be put into more than one place within the file.

For instance, a letter from Hiram Jones, giving current natural gas prices in Philadelphia, might very well be filed under the name "Jones." Since our memories aren't perfect, a search at a later date for information on gas, gas prices, natural gas prices, Philadelphia gas prices, 1955 prices, or some such, would depend upon the user's memory to recall the Jones letter, as well as the names of authors of all other letters which contained information on any of these subjects.

It is for this reason that a large or complicated or often-used office or research filing system does not operate satisfactorily; the office secretary is too often the butt of a frustrating exercise in the retrieval of information.

There are a number of *possibilities* for solution. The most obvious is to make multiple copies of the information, and then to file the copies in more than one folder. The cost of copies, file drawer space and filing time makes this impractical. An equivalent alternative, much less expensive, is to file all materials in any order which proves convenient, and then to prepare a card (or notebook) index file to your collection in the manner of a library catalog.

A complete set of cards describing each item in a number of ways must be made out, one to be filed under each heading. The production of multiple copies of records of this sort is economically feasible for many larger organizations, but the classification of printed material according to the subject systems used by libraries is quite complicated, costly and not entirely satisfactory for the average office to maintain. Too often, conventional classification systems are too general, too specific, out-of-date, inflexible, or cumbersome.

The system described here requires little investment of time and money, small maintenance cost, and affords complete access to all of the information in your files, regardless of the form of the material, whether it be a book, microfilm or a pamphlet. It can often be expanded to cover new subjects without revising what has gone before.

This method is probably best suited to files which will not become larger than 5000 items. For files larger than this, the possibility of machine-sorted (internally punched) cards should be investigated on an economic basis, taking into consideration the cost of buying or renting the equipment, the number of times the files are to be used, how fast the information is needed, etc., vs the cost of employing a clerk to sort cards by hand.

A typical edge-punched card (Fig. 1) has one or more rows of holes punched all or part-way along its perimeter. The blank space in the center of the card and on the reverse of the card can be used for written, typed or printed information. For each item to be entered in the filing system, it is necessary to make only one punched card. The card should contain a short but complete description of the item, e.g. "Letter from Jones, 9/2/56 quoting gas prices in Philadelphia for 1953 and 1954;" or, the card might bear the actual data. In addition, the card should indicate the location of the material, either by numerical reference, (e.g., File No. 346) or directly (e.g., Organization for European Economic Cooperation, Paris. 1953 Technical Assistance Mission No. 57. Production of drilling and refining oil equipment in the U.S.A. Location: Public Library, 665.6.068p), if the item is not "fileable."

Edge-punched cards are available in a variety of shapes and sizes from a number of manufacturers.[1] The cards

EXCLUSIVE

The Author

Alan R. Krull is in charge of the Technological Institute Library, and is also in charge of technical information for the Northwestern Technological Institute, Northwestern University, Evanston, Illinois. He uses his information gathering knowledge and technical background (electrical engineering) to administer the Technical Library, to edit publications of the institute, and to perform various public relations tasks. His most recent publication is "Transistors and Their Applications, A Bibliography, 1948-1953," published in the *Institute of Radio Engineers' Trans. of the Professional Group on Electron Devices*, August, 1954, pp. 40-77. Another bibliography, this time on artificial satellites, will appear shortly.

[1]Companies which can supply various forms of edge-punched cards (Consult telephone directory for local offices):
E-Z Sort Systems, Ltd., 45 Second St., San Francisco 5, California.
Charles R. Hadley Co., 330 N. Los Angeles 12, California.
LeFebure Corporation, 617 Oakland Road, N. E. Cedar Rapids, Iowa.
The McBee Company, Athens, Ohio.
Superior Business Machines, Inc., 307 5th Avenue, New York, New York.
Zator Company, 79 Milk Street, Boston 9, Massachusetts.

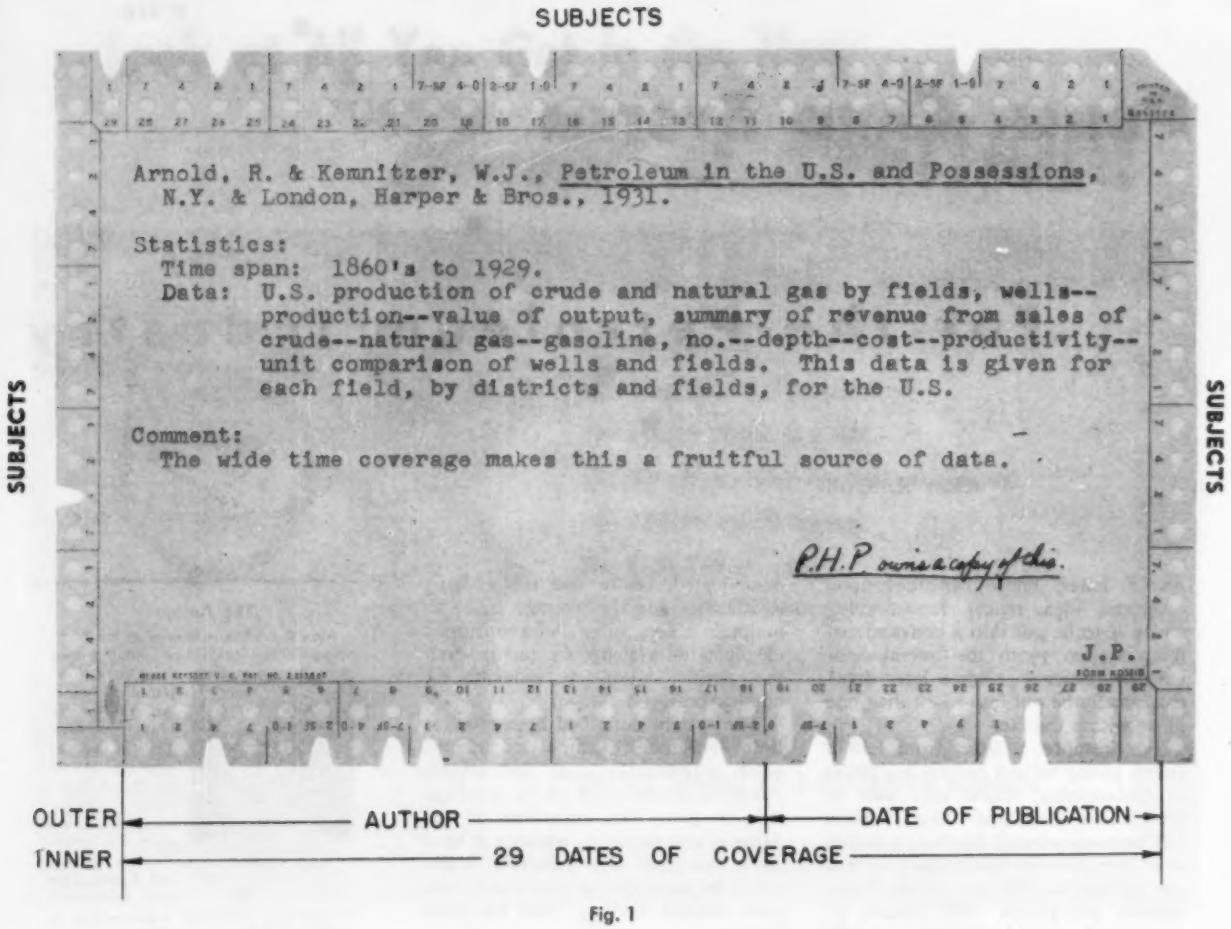
SUBJECTS
Arnold, R. & Kemnitzer, W.J., Petroleum in the U.S. and Possessions, N.Y. & London, Harper & Bros., 1931.
Statistics:
Time span: 1860's to 1929.
Data: U.S. production of crude and natural gas by fields, wells--production--value of output, summary of revenue from sales of crude--natural gas--gasoline, no.--depth--cost--productivity--unit comparison of wells and fields. This data is given for each field, by districts and fields, for the U.S.
Comment:
The wide time coverage makes this a fruitful source of data.
P.H.P owns a copy of this.
J.P.
SUBJECTS
SUBJECTS
OUTER
AUTHOR
DATE OF PUBLICATION
INNER
29 DATES OF COVERAGE

Fig. 1

also vary in paper quality, in the number of holes per inch, and in the number of rows of holes around the perimeter. Cards specially printed by the manufacturer cost more. Hand "punches" (really notchers), and sorting rods (knitting needles) can be purchased from the manufacturers.

Fig. 2A shows sections of cards which have been notched or punched with a hand punch. Corresponding holes have the same significance on every card. As shown, the "Jones" card is notched for the letter "J;" the appropriate holes are notched for Kooper and Hillman. Now if it is desired to retrieve all of the letters in your file from persons whose initial is "J," then the cards are lined up, a rod is inserted in hole "J" and passed through all the cards (Fig. 2B). When the rod is lifted all cards which have been notched at "J" will drop out. (All cards not so notched will hang up on the rod).

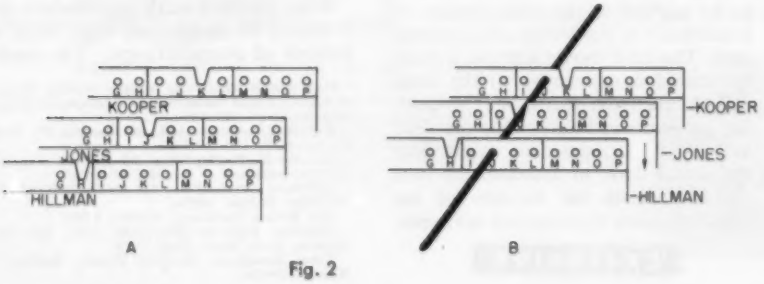

Fig. 2

Double Rows

A double row of holes may be punched or notched in any of three different ways, as shown in Fig. 3, shallow, deep or intermediate. By using only the shallow and intermediate positions, the inner and outer rows may be punched quite independently of each other, and therefore provide, in a direct punching system, twice as many coding possibilities.

Shallow notched cards may be retrieved by passing a rod through the shallow hole; all shallow notched cards (this also includes cards which are notched in both the intermediate *and* shallow positions) will drop out. To retrieve cards punched in the intermediate position, insert a rod in the inner position. All cards which drop all the way out will be those notched in both positions.

Cards punched only in the intermediate position will remain in the pack, but they will have dropped about ¼-in. Then, gripping the pack firmly, withdraw the rod and reinsert it in one of the outer corner holes, usually left unused. All cards punched in the intermediate position will then drop out. (Fig. 4.)

Coding Systems

Obviously, the coding system illustrated in Fig. 3 is wasteful. A glance at any letter file (or your telephone directory) will show that the initial letter "H," for instance, occurs many times more than "X," "Y," and "Z"

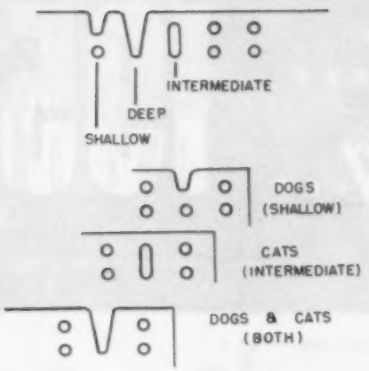

Fig. 3

combined. The most efficient coding system would divide the total number of items to be coded into equal numerical divisions.

If it were desired to divide all the letters in your file into 10 equal alphabetical divisions by author, a system could be devised as follows: Note the total number of pages in a large telephone directory. Divide the pages into 10 equal physical divisions, and then list the first name at the beginning of each tenth. Manufacturers of punched cards can supply more accurate tables for the division of names into 100, 200, 500 and 1000 sub-divisions.

By using 3 sections of 6 holes each, 18 holes in all, it is possible to code 1000 sub-divisions. Each section of 6 holes is numbered 7, 4, 2, 1, SF and 0 (Fig. 5). Each section can be made to indicate any number from 1 through 9. Number 1 is indicated by notching hole 1 and hole SF (which stands for "single figure." SF is notched whenever the single figures 7, 4, 2, or 1 are notched). Two is indicated by notching holes 2 and SF. Three is indicated by notching holes 2 and 1, but not SF, etc. Zero is indicated by notching hole 0 alone.

By assigning a consecutive code number to 1000 name divisions, 000, 001, 002, 003, 004, etc., the code number can be notched into the three sections of the card which indicate author. For example, if the code number for Ashburn were 028, then the card for Ashburn would be notched as shown in Fig. 5. Retrieval of this card could be effected in a number of ways.

One way would be as follows: Pass a rod through hole 0 in the field of the first digit. All cards which indicate a number whose code number begins with 0 would then drop out. This would include all cards from 000 to 099. Using cards which have fallen out, a rod is passed through holes 2 and SF, in the field of the second digit, either one at a time, or simultaneously, when using two rods at once. All cards which drop out will be for names whose code numbers began with 02. These cards, if they are not too many, could either be hand-sorted for Ashburn, or sorted by rod for the number 8 (7 and 1).

There are many other variations for name coding schemes.[2] This scheme also permits the cards to be easily arranged in numerical or alphabetical order by sorting in turn the numbers 1, 2, 4, 7, and placing at the back of the pack cards which drop out after each sort. Where there is more than one digit, sort the fields of 7, 4, 2, 1, SF and O from right to left.

Using this or a similar coding scheme, it may be seen that dates can be encoded using only two sections of 6 holes — '53, '54, '55, etc. (or three sections of holes for dates back to 1000 A.D., e.g. 1822 is represented by 822) if space on the card permits. Such numbers also may be punched directly into holes designated '53, '54, '55 or '56. Numerical data such as melting points can be punched onto the card in the same way; likewise geographical data, by dividing the country or the world into as many numerical divisions as desired.

The knottiest problem of all is to devise a coding system for subjects, whatever they may be, within the confines of the limited number of holes available on the card. Subject headings should be specific enough to describe exactly any given subject; at the same time, the system should permit a description of the item by more than just one subject heading. Such a system was devised for the Petroleum History Project.

[2]Casey, Robert S., and James W. Perry. Punched cards and their applications to science and industry. New York, Reinhold, 1951. This is the most comprehensive book on edge punched cards; it details all popular coding schemes.

Petroleum History Project

The Petroleum History Project at Northwestern University, Evanston, Illinois, was established in 1954 by a grant from the American Petroleum Institute. The purpose of the project is to prepare a complete history of the petroleum industry in America, and an analysis of the effect this industry has had upon American life. Frank M. Porter, president of the American Petroleum Institute has said: "This will be the first complete history of oil's dynamic growth and development. It will encompass 100 years of civilization, a period of social, human, technological and economic advancement without precedent." The director of the Petroleum History Project, Dr. Harold F. Williamson (professor of economics and chairman of Northwestern University's committee on business history) has said "Not only is this the first attempt to survey the entire industry, but it is being carried out under an agreement that incorporates the university's standards of objective research and writing." The immensity of such an undertaking is apparent, involving the collection, storage, classification and appraisal of thousands of bits of information, each of which may have a bearing on any of the other aspects of the

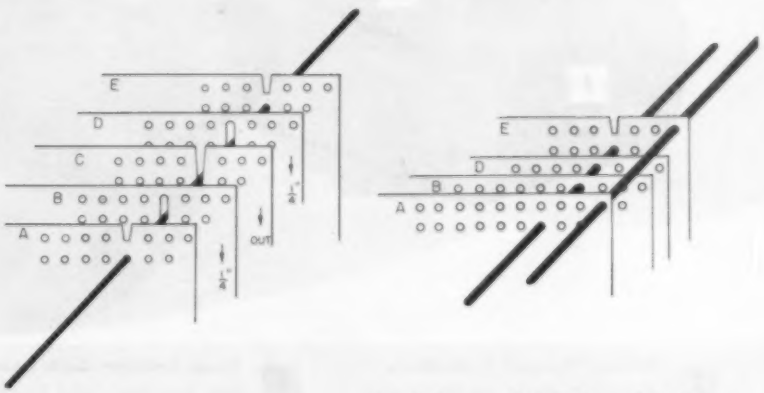

Fig. 4

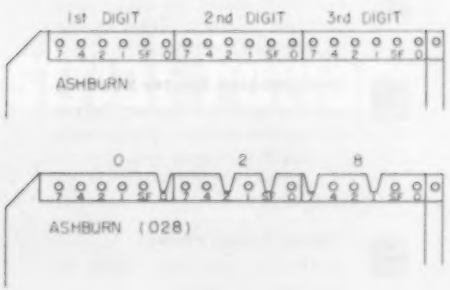

Fig. 5

NOW *bid beating... dirt heaping...* 1956

10% bigger payloads!

Model "75"... boosted to 20 yds heaped (without sideboards)... 262 hp.

Model "55"... boosted to 14 yds heaped (without sideboards)... 172 hp.

Wide-base tubeless tires and windshield, shown, available as optional equipment.

1. **Wider "Target" Push-Block** makes it easier to make and maintain contact. Helps to cut loading and cycle time.

2. **Straight-Line Ejector Reeving** requires minimum power; leaves more power on Payscraper wheels for faster dumping and spreading. Also speeds re-threading time.

3. **Sturdy Cover Plates** protect new, stronger cylindrical ram and air tanks.

4. **New, Straight-Back Bowl** lets you heap and haul more dirt every trip. Struck capacity, *with sideboards*. 18 cubic yds on "75"—12 cubic yds on "55".

5. **Higher Apron Lift,** bigger apron opening, provides cleaner, more rapid dumping, especially of "sticky" materials.

6. **Fast-Acting Apron,** arms mounted outside bowl, assure quick, positive closing of apron. Payscraper holds the load from cut to fill.

7. **Lowered Draft Frame** provides operator with "control tower" visibility of bowl and push-tractor... also helps direct push and pull power more efficiently to cutting edge for faster loading.

8. **Larger, Wider Fenders** give greater safety for operator, greater protection for machine.

International Payscrapers®

Put the 1956 International Payscraper to work on your job, and watch dirt boil up into its new, straight-back bowl. You've never seen any big scraper load as easily or as fast. In seconds, you've packed in up to 23 heaped yards. Its offset 3-section blade breaks the ground like a sharp-pointed spade. Dirt boils from the smooth-slicing cutting edge and fills the corners to build a full heaped load. Close the apron instantly, positively, on this huge, well-compacted load and you carry all the dirt you've heaped in.

Now, drive easily, effortlessly with safe hydraulic power steering at a fast clip to the fill. Note how the 1956 Payscraper's extremely high ratio of horsepower to capacity and its rapid acceleration to 24 mph top speed add up to more trips per hour than any other self-powered scraper you've ever used. Yes sir, it's a real profitable dirtmover, this 1956 Payscraper! Try one yourself on your job! See your International Industrial Power Distributor for a demonstration.

Maximum 52° Oscillation
from right to left takes the stress and strain out of hauls over furrows, rough ground.

Adjustable 3-Piece Cutting Edge
for clean, fast cutting and loading under all soil conditions.

New, Long-Lasting Clutch
of ceramic material and powdered metals, successfully resists heat and wear over longer periods. Available on Model 75 only.

INTERNATIONAL HARVESTER

International Industrial Power

INTERNATIONAL HARVESTER COMPANY, 180 N. Michigan Avenue, Chicago 1, Illinois

A COMPLETE POWER PACKAGE INCLUDING: Crawler, Wheel, and Pipe-Boom Tractors . . . Self-Propelled Scrapers and Bottom-Dumps . . . Tractor and Rubber-Tired Loaders . . . Diesel and Carbureted Engines . . . Farm Machinery . . . Motor Trucks.

Ever read a guarantee to beat this?

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Our distributors are authorized to put a Gorman-Rupp Self-Priming Drainage Pump on any job, any time, anywhere alongside any other make of pump, size for size.

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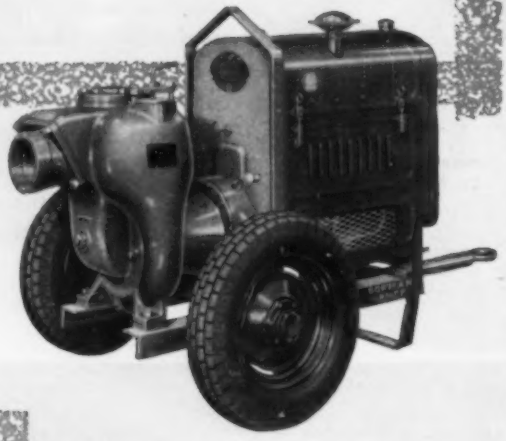

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Gorman-Rupp PUMPS

Write for Bulletin No. 5-OF-11

Mid-Continent & Gulf Coast Oil Field Representative
HENRY H. PARIS DISTRIBUTOR, INC.
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project. The study is to culminate in 1959 with the publication of a two-volume history.

To organize and standardize its collection of information, as well as to make the information available to all members of the project, it was decided that an edge-punched card system was to be used. A system has evolved which, taken as a guide, can be helpful in working out other systems for use in the petroleum industry.

It should be borne in mind that this system is in a dynamic state. Cards are always being added to the file; cards are being used constantly; subject interest varies from time to time. Changes or variations in the coding system may have to be made, either to correspond with the current interest of the project, or because of changes in terminology. It is not always possible to anticipate the need for certain subject headings in advance of the collection of information, and for this reason, blank spaces were left in the subject scheme.

Fig. 1 shows a representation of the card used by the project with an indication of subject heading assignments on the card. The complete subject list is shown in Table 1. Usable space is 7¼-in. by 3¾-in. on both front and back of the card. It is thus possible to make a rather lengthy note on the card; if more space is required for notes, one of the following alternatives may be pursued:

A. Continue the note on another punched card, label the cards Card 1, Card 2 and so forth, and punch all of the cards in the same manner.

B. Indicate on the face of the card only the subject content of the article and refer to the original by bibliographical reference or by number. For instance: "Vapor Pressure Chart for Volatile Hydrocarbons. See Photostat No. 52 in files. From Petroleum Enengineer, July, 1953, p. E-29."

Subject Coding System

Since it was found that many bibliographical items need more than one classification to describe them completely, a word-coding scheme was conceived which could describe the item in more than one way and at the same time would not use up all the holes on the card. In this system an article giving production figures for a certain year is *not* indicated by notching a hole labelled *production statistics*. Rather, one hole is assigned the subject *Production*, and another hole is labelled *statistics*, and both are punched.

Each of these holes may be used in conjunction with any of the other

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Pressure of explosive force merely opens out safety back

Instead of depending on blow-out plugs, entire back of Safecase Gauge is designed to yield to over-pressure. Photo at left shows actual result of firing cartridge within back of case. Safety-release back exhausted pressure. Front remained intact.

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"THE STANDARD OF ACCURACY"

MARSH GAUGES

TABLE 1. Petroleum History Project.

Subjects and Dates of Coverage

Top of card ("O" indicates Outer Row)

1	Bibliography	15	West Coast
01	Federal	015	Foreign (and export)
2	Biography	16	
02	Inter-, intra-state, local	016	
3		17	Exploration and drilling
03	Government document	017	Production
4		18	Geology, geography, history
04	Patent	018	Other sciences and technology
5		19	Refineries
05	Statistics	019	Refining and distillation
6		20	
06	Court case, law suit	020	
7		21	Railroad
07	Periodicals and serials	021	Pipe lines
8		22	Transportation (other)
08		022	Tidelands
9	Kerosine	023	Standard Oil Co.
09	Crude oil	24	Minor companies
10		024	Other major companies
010	Gasoline	25	
11	Medical and other uses	025	Construction
011	Lubricants	26	Finances, earnings
12		026	Costs
012	Other petroleum products and fuels	27	Securities, speculation
13	Penna., Ohio, Allegheny, New York, West Virginia	027	Prices
		28	Estimates, resources
013	Atlantic Coast (including Philadelphia, Penna.)	028	Marketing
		29	
14	Mid-Continent, Gulf	029	Supply
014	Rocky Mountains		

Left margin of card		Right margin of card	
30		48	Investigation (trust, government)
31	Labor, employment	49	Regulation
32	Safety, accidents, health	50	Laws and legislation
33		51	Competition
34	Insurance	52	Integration
35		53	
36	Public relations	54	Management
37		55	Associations and trade agreements
38	Waste, waste disposal, pollution	56	
39	Conservation	57	Social impact
40		58	Taxation
41	Production rate, productivity	59	
42		60	Research
43	Illumination	61	
44		62	Inspection, testing, standards, quality
45	Other related or competitive products and industries	63	Equipment and packaging
		64	Storage
46			
47			

Bottom of card (inner row)

1	1921 +	11	1886 — 1890	21	1936 — 1940
2	.... — 1845	12	1891 — 1895	22	1941 — 1945
3	1846 — 1850	13	1896 — 1900	23	1946 — 1950
4	1851 — 1855	14	1901 — 1905	24	1951 — 1955
5	1856 — 1860	15	1906 — 1910	25	1956 +
6	1861 — 1865	16	1911 — 1915	26	.... — 1872
7	1866 — 1870	17	1916 — 1920	27	1873 — 1893
8	1871 — 1875	18	1921 — 1925	28	1894 — 1911
9	1876 — 1880	19	1926 — 1930	29	1912 — 1921
10	1881 — 1885	20	1931 — 1935		

holes on the card to indicate, for example, *storage statistics, kerosine statistics, refining statistics, regulation of production,* etc.

One, two, or more holes may be notched to describe any item. In addition, other subjects which may be contained within the same article, may be described concurrently by notching them into the punched card. Only infrequently, when a variety of subjects are punched onto the same card, will cards drop out which bear relation only partly to the exact subject called for, but these may be sorted out by hand in a few moments.

An inspection of Table 1 reveals that subject headings have been made to cover the following general aspects which proved important for the Project. These are bibliographical distinctions (bibliography, document, patent, periodicals, etc. . . .) product distinctions (kerosine, crude oil, lubricants . . .), geographical divisions (Allegheny, Atlantic Coast, Mid-Continent, Gulf . . .), processes and/or actions (refining, drilling, marketing . . .), legal-financial concepts (regulation, competition, integration . . .) plus other miscellaneous classifications.

Dates

Dates of publication are punched into the card in the section shown, 19th century dates are indicated by punching the hole below the trademark (lower left) in addition to punching the other two digits. It also was discovered that the date of publication of a particular article or the date on a letter, did not always provide temporal access to the information. For instance, a paper published in 1920 might contain some interesting figures on the industry during the years 1900-1915. The date of publication in this case is not as significant as the "date of coverage."

The important dates (1900-1915) can be indicated by notching holes 13 through 16 at the bottom of the card in the "date of coverage" section. Therefore in order to obtain all sorts of information pertaining to the years 1900-1915, rod holes 13 through 16. All cards which drop out then will deal with all or some of those years. "Date of coverage" is punched directly into the card; no further encoding is necessary.

Machine vs Hand-Sorted Cards

Any of the basic information given about edge-punched cards applies to the machine-sorted card. These cards are both punched and sorted by machines which are usually rented from the manufacturer. The speed and accuracy of machine sorting is greater, of course, than hand-sorting. It is also possible to rent or buy various mechanical aids for use with edge-punched cards. Manufacturers of machine-sorted or internally-punched cards[3] can supply information about rentals and advice on problems involved in setting up a system.

It is also possible to combine the machine sorting systems with other accounting devices to perform computing, printing, duplicating, addressing and many other functions. The field of "integrated data processing" can also affect certain other efficiencies where it is desired within a company to record all data centrally and to distribute it wherever needed. Decisions on various systems must be made on an economic basis, as suggested before, but whether a machine-sorted or hand-sorted system is used, the problem most difficult to solve and yet most vital for workability is the selection of the subject coding system.

[3]International Business Machines Corporation., 590 Madison Avenue, New York 22, New York.

Remington Rand, Inc., 315 4th Avenue, New York 10, New York. ★ ★ ★

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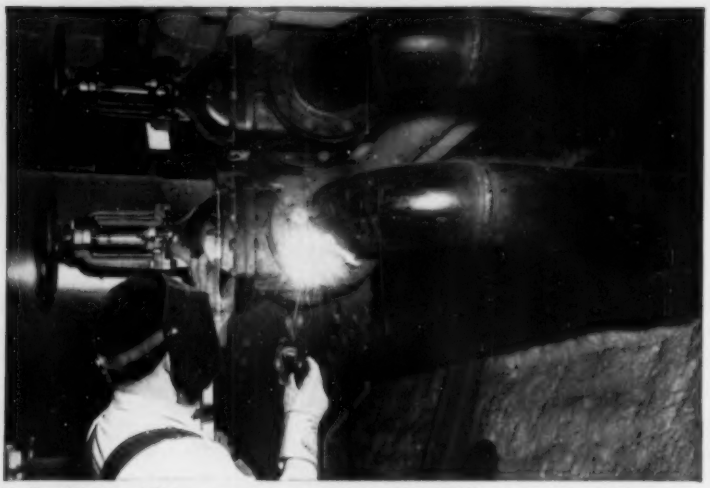

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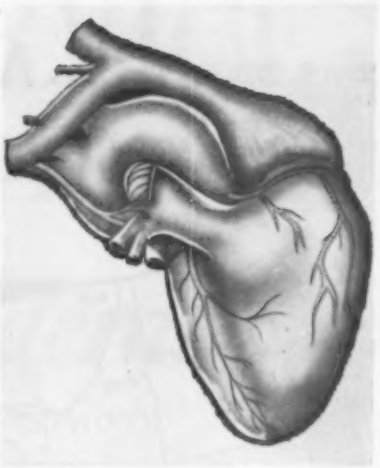
The Matter of THE HEART



One specialist says there is an "epidemic" of coronary thrombosis. . . . This brief description tells what the disease is and what to do about it.

Kieffer Davis, M.D.*

DURING the past few months, many of us have become more personally interested in heart disease and heart ailments — particularly coronary occlusion.

Current magazines and publications have pretty thoroughly covered this subject, from causes to treatment. However, since this health problem is of such increasing importance in today's living, a brief discussion of it in abstract form may be well worthwhile.

In the beginning, it might be wise to remind you that the heart is essentially a hollow organ that pumps blood through the body. It has been calculated that during the ordinary span of a man's life, the heart beats about 2600 million times, pumping at least 150,000 tons of blood . . . a rather remarkable feat when you figure this is equivalent to moving a weight of 10 tons to a height of 10 miles.

What Can Happen

In order to carry out this tremendous amount of work necessary to life, the heart, like any other organ of the body, must have a blood supply of its own. The blood, which supplies nutrient material, is carried to the heart by a system of vessels called coronary arteries. This system is comprised of two main coronary arteries (*see cut*) that branch out to supply blood to all parts of the heart muscle. When one of these arteries becomes obstructed, or plugged off, the condition is termed coronary occlusion, or sometimes, coronary thrombosis. When a vessel is plugged off, that portion of heart muscle nourished by the plugged artery then dies. Knowing this, it is easy to understand that the amount of damaged heart tissue depends entirely upon the location and size of the vessel plugged off.

What is a "Coronary Occlusion?" To understand this, one might visualize the inside of an abnormal coronary artery as an old water pipe partially closed by an accumulation of boiler scale. As you know, such an accumulation of scale will retard the flow of liquid. A similar narrowing process takes place in diseased coronary arteries, brought about by an accumulation of fatty deposits within the wall of the vessel. This narrowing of the opening results in slowing down the flow of blood and will ultimately lead to clotting, or occlusion.

Diet Is Important

Recent studies have revealed that coronary occlusion is not necessarily an inevitable process associated with aging but is actually a disease in which diet plays a major role. We know, too, that coronary occlusion has no affinity for any special age group for experience has dictated that individuals in their 20's and 30's can be affected also. Although coronary occlusion is most frequent after the age of 45, the beginning of this disease may occur in the earlier years. With this knowledge, we feel that obesity in younger individuals is one of the factors that may lead to coronary disease. Many other factors are involved in coronary disease, true, but the one most easily controlled is that of diet.

Symptoms of coronary occlusion are quite variable. If a small vessel is occluded, it might be mild or even go unrecognized. On the other hand, if a coronary vessel of larger caliber is suddenly occluded, the symptoms will be severe. They include pain ordinarily located under the breast bone but which can and does in many instances radiate to one or both arms, to the shoulder regions or even the neck and jaw. At times, particularly in the more severe cases, this pain is constricting in nature, like a band being tightened about the chest or a heavy weight on the breast bone. Associated with this pain may be shortness of breath, sweating, pallor, weakness, nausea and vomiting. The extreme case may culminate in shock and prostration.

Let Your Doctor Decide

Coronary occlusion constitutes one of the major medical emergencies. Even though there may be other conditions of less serious nature, such as gallbladder disease, neuralgia, pleurisy or indigestion which mimic symptoms of coronary occlusion, it still remains that the family physician should be called in to make the differential diagnosis.

Not too many years ago, the individual who suffered a coronary occlusion and recovered was oftentimes considered a cardiac invalid. Today, we know this is not true for statistics prove that 90 per cent of all people having their first attack live and that the majority are able to return to their usual work; so there is little need in the usual case for the affected person to become a "heart cripple." It is even conceivable that today's intensified research work in heart disease may lead to better methods for early diagnosis and control of this disease in the near future. ★

Reprinted from Philnews, January, 1956.

*Dr. Davis is medical director of Phillips Petroleum Company.

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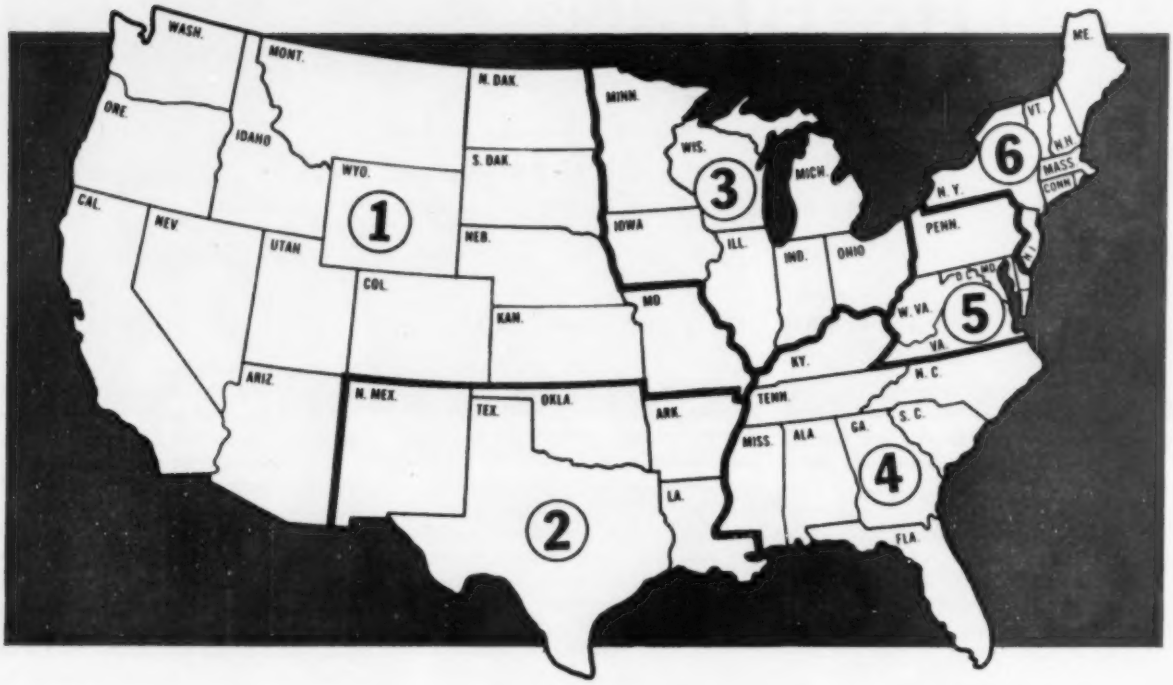

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The Philosophy of READING

Ralph M. Besse*

FRANKLIN D. ROOSEVELT, while President, called on Justice Holmes one evening. Mrs. Holmes told the President that the Justice would be glad to see him, although it was interfering with the Justice's reading program. Roosevelt, when ushered into the room, said to Holmes, who was then past ninety, "Mr. Justice, why do you work so hard at this reading business?" Holmes replied, "I know of no other way to improve my mind!"

Holmes had recognized a number of things in that sage remark. One is that education is a continuous process. You don't "become educated" at college. You are merely prepared for an education. To be an educated person you must study continuously as long as you live, and Holmes knew that.

The second thing Holmes recognized was that to achieve mental improvement, you have to do it yourself! Essentially, nobody else can educate *you*. And that holds whether you're learning the characteristics of Chaucerian style or the rudiments of the free market economy.

While reading is admittedly indispensable to the self-improvement process, relatively few of us find the time to do much serious reading.

The Research Institute of America made a poll of executive reading habits. I think the 5.4 per cent who refused to say what they read can safely be classified with 4.6 per cent who *admitted* they read nothing. That makes a total of 10 per cent who did not read. Further, 21 per cent read only 1 to 6 books a year, and 23.6 per cent from 7 to 12 books yearly. That makes a total of almost 60 per cent who read 12 or fewer books per year.

Why don't people read more? "Because I don't have time!" That is far and away the major reason given.

There are two ways to find time to read. First, you must create the desire to read. Second, you must adopt some simple techniques to help establish the reading habit.

During the war years, I dropped book and heavy magazine reading and spent most of my time with newspapers — to keep pace, I reasoned, with history in the making. That sounded like a logical decision, and I got almost completely out of the habit of reading books for three or four years.

Then suddenly, it occurred to me that I wasn't learning much from newspapers, and not a great deal more from current news magazines — that is, not much of lasting value. So in spite of radios, three children and a television set, I concluded I had to go back to some serious kind of reading.

To encourage your own desire to read, you should be aware that two of the most important creators of interest are the things you feel responsible for and the things you get credit for doing. Hence, initial reading programs should be directed at something you like, that will help in your job, something which will bring you recognition, or that is related to things you feel responsible for. And those things for which you feel responsible can range all the way from your own home to aiding in the preservation of individual freedom.

Now, how do you actually get started reading? What are some simple techniques? First, you should realize that serious reading takes less time than many persons imagine. If you spend just 15 minutes a day, reading at the average rate of 300 words a minute, you will read a million and a half words a year — or an average of 20 books! But, of course, you have to devote these 15 minutes *every* day.

Sir William Osler, who was one of the greatest medical teachers of all times, did exactly that. He would take 20 minutes each day, as I recall, and he became one of the best-read doctors in the United States. I guess he cheated on the long side and would sometimes read much longer than that — but the core of his reading was a 20-minute schedule, either just before he got up in the morning or just before he went to bed at night.

Another step is to make a time chart of your day. Find out what you do with your time. Most people don't know. Once you have found what your time-schedule is — once you have charted it — you can begin planning, and very likely you will find additional moments for reading.

Also, you will learn that you can read at almost any time, and in almost any place — even in the bathroom. I have read in the bathroom for years. I just finished reading Herman Melville's great *Moby Dick* in the bathroom. I had wanted to read that book for a long time, and that's how I did it!

Another suggestion. Read on the way to work. When I come to work on the Rapid Transit, I see many people sitting in their seats either dozing or looking idly out the window. They could be using that time to great personal advantage — reading a good book.

Newton D. Baker was an unusually well-read man. He was also a busy man — busy enough to have been Mayor of Cleveland and Secretary of War during World War I. He also founded a law firm and did much public speaking. But in spite of that kind of busy life, Newton D. Baker had read literally thousands of books. Asked how he did it, Baker replied, "I just fill in the little fence corners of my time reading."

By that he meant, he always had something at hand to read; and whenever he had time — even 5 or 10 unexpected minutes — he would pull the material out of his pocket or brief case or off his desk and begin to read. So always carry a book or serious magazine with you — or keep one handy.

Another technique I find helpful is to read more than one book at a time. I read from 8 to 10 books at a time, for the reason that I'm not always in the same mood. Some evenings I will sit down fresh and vigorous and want to read something in science or nature or politics. Another time I may be tired and prefer something a little lighter. So I try to keep a variety of books on the move.

To really get started on such an extensive reading program, your own personal philosophy must have led you to certain deep convictions. Very likely you believe that education — especially *self*-education — is a good thing. Probably you want to assume your responsibility for good citizenship — you want to be a good citizen, wholly aside from your job or other personal responsibilities. And probably you want to improve your job performance, whether you're a mother and homemaker, or a corporation executive.

These three things have one point in common — all require *learning*. Now,

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*Mr. Besse is executive vice president of Cleveland Electric Illuminating Company.

there are only three ways to learn:

1. From others
2. By thinking things out yourself
3. By experience.

I wouldn't discount the value of experience, but it is a very slow way of getting a really broad education. Thinking things out for oneself is even a better way — to the extent that we do it. But the quickest and most effective way is to learn from others — from the experience and thinking of millions of people over hundreds of years.

You can learn from others either by reading, by taking instruction, or by observation — or by a combination of these. But there is relatively little opportunity for observation, and not enough time for continued personal instruction. So that brings us back to reading as the most valuable learning method.

Reading is actually the key to learning. Why? To put it briefly, because it is the most complete, most available, cheapest, quickest and most current source of learning! Further, it is a system of multiple learning — you learn more than one thing from good reading. And it is a method of continuous personal training for self-improvement.

First, reading is the *most complete* source of learning. Francis Bacon observed that "reading maketh a man," and Thomas Carlyle said:

"All that mankind has done, thought, gained or been: it is lying as in magic preservation in the pages of books."

There is no knowledge, practically speaking, that is not recorded some place in writing. The whole realm of knowledge known to man is written out — with very few exceptions.

I have also said that reading is the *most available* source of learning. This scarcely needs proof. We can have magazines and other good literature routed directly to our desks or homes. We can buy it in almost any city block. We can borrow it from company or public libraries. It is readily at hand.

Further, reading is the *cheapest* source of learning. Almost all reading matter is available without any direct cost whatsoever — at a library. And even reading material that is inconvenient to borrow need not be expensive.

Again, reading is the *quickest* source of learning. Certainly it is far faster than formal instruction, experience, observation or thinking things out. Remember, the work of a lifetime is often recorded in a single book.

Also, reading is the *most current* source of learning. Change is a major characteristic of our day. If we are to be effective, we must keep pace with change. Many things we learned in college may no longer apply. We can't keep going back to school — but we *can* read!

I also observed that reading is a system of multiple learning. In reading a single book, we are apt to derive several different values. We learn the author's viewpoint or perspective, his analysis. We get sheer information or knowledge. We learn vocabulary. We can acquire a better form of expression by studying a good writer's style. And often, we get entertainment value too.

Finally, reading is a method of continuous personal training for *self-improvement*. It constantly challenges your thinking processes and so can train you in good habits of thinking. It provides the discipline for gaining new fields of knowledge. Reading allows you to train yourself. And this self-training becomes easier the more you read. Each broad field of knowledge you add to your store helps in other fields of knowlege. As Alfred North Whitehead put it:

". . . The more you know, the easier it is to add to your knowledge."

Reading is the key to learning. . . . . It is the most complete, most available, cheapest, quickest, and most current source of learning. . . . It is a method of continuous training for self-improvement.

Having touched on the merits of reading and the techniques of going about it, we naturally come to the question: What shall I read? The answer varies greatly from person to person, but here are some comments that may have broad application:

Newspapers. There is some opinion among great minds that newspapers are a waste of time! Justice Holmes thought that, and certainly the word-by-word reading of the average daily paper is not justified. These papers should be skimmed. This is the place for speed reading — with a great deal of skipping. But do not skip editorials; they should be the most important part of a local newspaper.

Magazines. Here, generally, is a higher grade of writing. Newspaper reporting rarely permits the kind of investigation possible in magazine writing. A specialty magazine is certainly a must. If, for example, your specialty is business management, you are apt to find the *Harvard Business Review* invaluable.

[Editor's Note: If you are interested in learning more about petroleum management and engineering, *The Petroleum Engineer* is a must.]

Miscellaneous Publications. A check at your library will reveal there are a great many of these. One type is the "economic letter." Some of the banks put these out. In the field of economics and government, a great many excellent pamphlets, booklets and articles are available from the Foundation for Economic Education, Irving-on-Hudson, New York.

Books. Books present the finest of all reading opportunities. The greatest thinking of the finest minds, the finest expression of the greatest writers and the most profound learning of qualified experts in every field and every age is available in books.

Everyone must decide for himself what books he should read; but in the selection of books by subject matter, there is an old adage that is well to keep in mind: "Shallow minds are concerned with people. Average minds are concerned with events. Great minds are concerned with ideas." More specifically, here are some pointers on book selection:

1. Don't hesitate to reread the very good books.
2. Don't hesitate to read only a part of a book — if only a part serves your purpose.
3. Try to read only the *best* books.
4. Don't hesitate to read a cheap, paper-backed edition of a good book.
5. Don't be afraid of any subject merely because it is published in a book.

And now, let me conclude with some observations on *how to read*. Read with a definite purpose — according to a plan. Get acquainted with a book before you read it; take a few moments to investigate before you spend a few hours reading. Evaluate what you read — learn to reflect, analyze, challenge, as well as understand.

Keep an open mind as you read; don't limit your reading to what you already know and believe. Study vocabulary as you read — learn more words and the exact meaning of words. Study phrases as well as single words, and learn to avoid cliches. As you read, concentrate. Keep searching for ideas.

Finally, talk about what you are reading. People will listen to what you have to say about the books you are reading. At the same time, talking about books you're reading helps fix the ideas in your own mind and sharpens your ability to analyze the opinions of others. ★ ★ ★

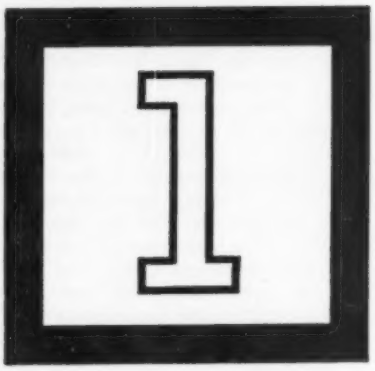
SHELL Launches New Safety Series

All over the country people are seeing Shell Better Driving Quizzes like the one on the right and those below.

Behind this new campaign lies Shell's conviction that part of our job—as a major supplier of gasoline and oil products—is to promote driving safety. That's why Shell started the famous "Share-the-Road" club back in the late 1930's. That's why we established the Carol Lane Awards for women's efforts toward traffic safety.

This new safety series urges the reader to test his reflexes, eyesight, knowledge of road signs, driving attitudes. No longer can the reader shrug off a safety message as written for "the other fellow." First indications are that these advertisements actually are helping many drivers think more seriously of their highway habits. That's a sure sign of a better future for all of us.

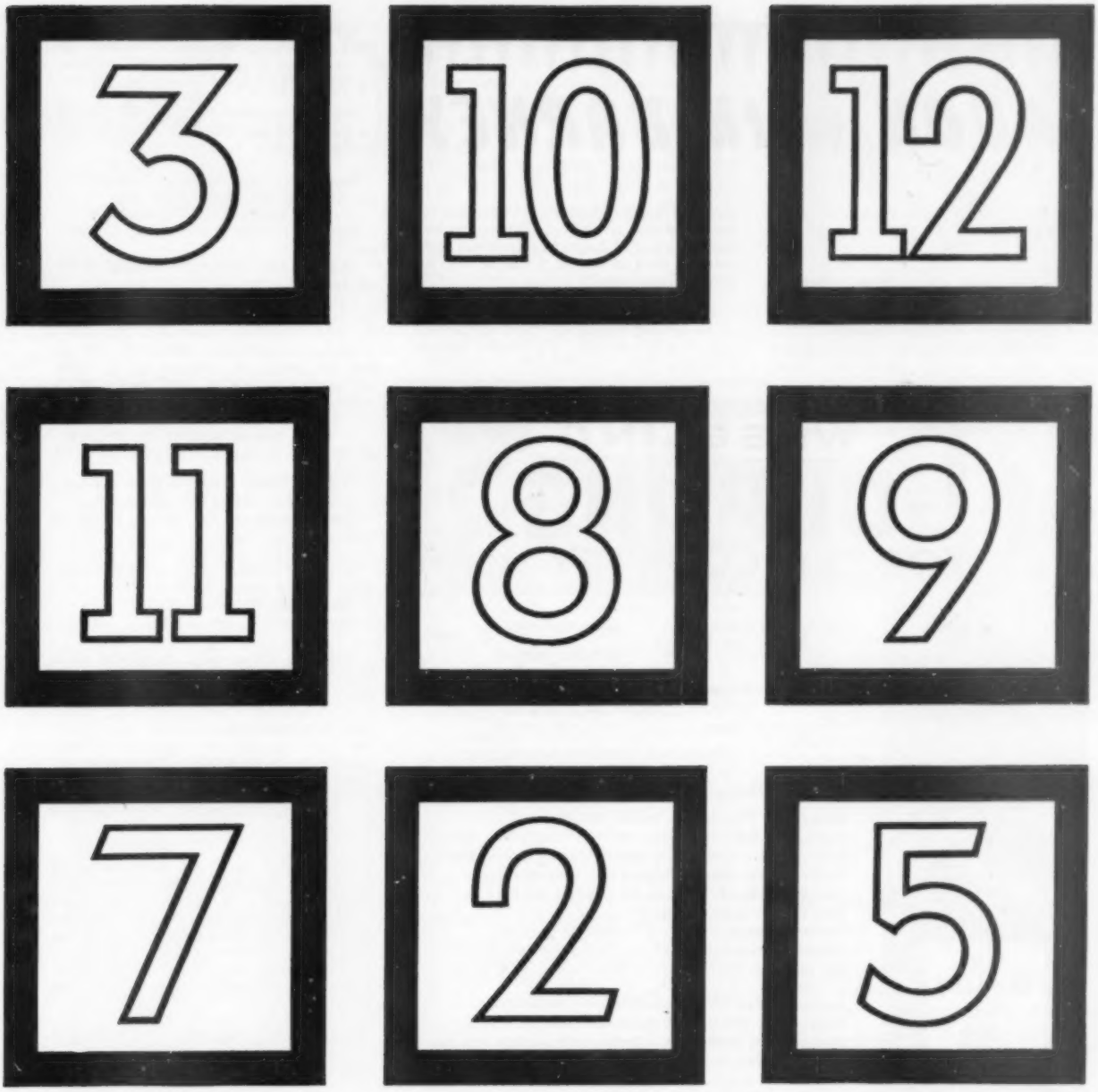
Can you tell a road sign by its shape?
Read and obey your signs of life!
SHELL OIL COMPANY
How far from the car in front should you be at 50 mph?
Stay Back! Don't Crowd Your Luck!
SHELL OIL COMPANY
See how fast you can move to the brake!
BRAKE
GAS
SHELL OIL COMPANY
Check your driving attitudes
Drive right...enjoy your right to drive
SHELL OIL COMPANY



TRY THIS BETTER DRIVING QUIZ!

It helps you relate your reaction time to safe driving speeds. Others in Shell's public service series on driving safety highlight such factors as courteous attitudes and recognition of road signs.

SHELL



HOW FAST CAN YOU TOUCH EACH SQUARE IN NUMERICAL ORDER?

WITHIN 9 SECONDS? Your reflexes are about average.
WITHIN 7 SECONDS? Very good.
WITHIN 5 SECONDS? Excellent.

MORE THAN 9 SECONDS? YOUR REFLEXES ARE TOO SLOW. DON'T DRIVE OVER 45 M.P.H.*

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*Authority Dr. Herbert J. Stack, Director, Center for Safety Education, New York University

LAUGH with BARNEY

When a family man pulls out a fat wallet you can be sure of two things — he has a camera and a child.

A young soldier called on a 16-year-old girl, and remarked to her parents that he was from Philadelphia.

The girl's father commented that he and his wife were married there 17 years years ago. A startled expression passed over the soldier's face. Next morning the daughter said in disgust, "That certainly did it, Father. I had told him I was eighteen; so then of course, I had to tell him I was illegitimate."

One of these days somebody's going to come up with a book on "How to Get Out of Doing It Yourself." He'll make himself a fortune.

WHEELING
COUPLINGS
FOR OIL COUNTRY USE
LINE PIPE COUPLINGS A.P.I.
⅛" to 12" — Seamless and Special Processed — Black or Galvanized
PLAIN TUBING COUPLINGS A.P.I.
1" to 4" — Seamless
EXTERNAL UPSET TUBING COUPLINGS A.P.I.
¾" to 3½" — Seamless
CASING COUPLINGS A.P.I.
4½" to 13⅜" — Long or Short
HYDRAULIC COUPLINGS
⅛" to 4" — Seamless
REAMED AND DRIFTED A.I.S.I.
¾" to 12" — Seamless or Special Processed
DRIVE PIPE COUPLINGS
⅜" to 12" — Seamless or Special Processed
Sales Offices in Leading Cities:
Albany, N. Y.—Albert L. Becker, 434 Clinton Ave.
Baltimore, Md.—Ted Barto, 2301 No. Charles St.
Chicago, Ill.—Harry A. Jay, Suite 1090, Old Colony Bldg.
Denver, Colo.—Earl H. Jones & Co., 1863 Wazee St.
Detroit, Mich.—R. W. Lang, Jr., 505 Park Avenue
Erie, Pa.—R. J. Maggi, Box 711
Falmouth, Mass.—Walter S. Bennett, 53 Minot St.
Houston, Texas—Henry H. Paris Distributor, Inc., Box 932
Los Angeles, Cal.—James A. Riordan Co., 1400 Santa Fe Avenue
Louisville, Ky.—Sid. Schultze Co., 514 W. Main St.
Milwaukee, Wis.—M. A. Nelson Co., 3347 N. 97th St.
Minneapolis, Minn.—Lin J. Kraust, 5605 Lyndale Ave. S.
Narberth, Pa.—J. W. Worthington, 105 Forrest Ave.
Newark, N. J.—Ira L. Rothenberg & Assocs., Industrial Office Bldg., 1060 Broad St.
New York, N. Y.—Max Rothenberg, 11-05 38th Ave., Long Island City
Oswego, N. Y.—Northeastern Associates, Inc., Neil Chatterton, Secretary, P. O. Box 284
Portland, Ore.—Earl H. Jones & Co., 1233 NW 12th Ave.
Richmond, Va.—P. C. Abbott & Co., 15 E. Franklin St.
San Francisco, Cal.—Earl H. Jones & Co., 1150 Folsom St.
Seattle, Wash.—Earl H. Jones & Co., 819 Thomas St.
TOP QUALITY Since 1918
WHEELING MACHINE PRODUCTS COMPANY
WHEELING, WEST VIRGINIA
Factories at WHEELING, W. VA. and WOODLAKE, CALIFORNIA

YOUTH — When you can be a college track star during the day — but can't go to the corner drug store at night without the family car.

Pity the minister who bought an old used car, and then didn't have the vocabulary to run it.

Patient: I'd like to have a quarter removed from my stomach, Doctor.
Doctor: When did you swallow it?
Patient: I think it was about 15 years ago.
Doctor: And you're just coming to see me now?
Patient: Well at the time I didn't need the money.

Bars are something which, if you go into too many of, you are apt to come out singing a few of, and maybe land behind some of.

A feller was practicing on his saxophone late at night when the landlord came in.
"Do you know there's a little old lady sick upstairs?" asked the landlord.
"No," answered the feller. "Hum a little of it."

A driller putting child to bed: "Now what are you crying for?"
Small Son: "I wanna drink."
Dad: "So do I. Go to sleep."

The only thing more dangerous to a bachelor than a jealous husband is a single girl.

A none-too-modest hunter, on a hunting trip, took aim and fired, but the bird sailed on undisturbed. The marksman watched it in dazed silence then dashed his gun on the ground and shouted, "Fly on, you blankety-blank fool bird! Fly on with your gol-durned heart shot out."

A motorist and his wife traveling through the Blue Ridge Mountains of Tennessee stopped at a one-pump gas station before a mountaineer's cabin. After the man told the proprietor to fill the tank, his wife asked: "Is there a rest room here?"
"No, ma'am, there isn't, but you'll find a mighty comfortable rocker up there on the porch."

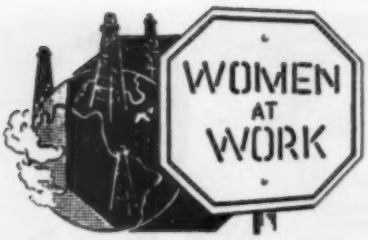
Following sign was recently observed in a cocktail lounge in Dallas: "Please do not stand up while room is in motion."

Housewife (hiring new maid): "And how much wages do you expect?"
Applicant: "That depends. Do you peel or unfreeze?"

The children were in the midst of a free-for-all when father unexpectedly entered the room.
"Tommy, who started this?" he asked.
"Well," replied Tommy. "It all started when Albert hit me back."

An old Indian took his watch to be repaired. When the jeweler took the back off, a dead bug fell out.
The Indians astonished, exclaimed.
"Ugh! . . . No wonder watch stopped . . . engineer dead!"

The baby sardine saw its first submarine, and went swimming in terror to its mother. "Don't be frightened, darling," she reassured him, "it's only a can of people."



Technical Editor

"Comprehensive, accurate and highly informative." That's how one of the nation's foremost scientists appraises SCALACS, regional bulletin of the Southern California section of the American Chemical Society, which is being edited by a woman for the first time in its 11-year history.

The editor: Elizabeth Walkey, research librarian at Consolidated Electrodynamics Corporation, Pasadena, California. The scientist: Dr. Arie J. Haagen-Smit, Caltech professor who is chairman of the Southern California ACS section.

"Betty" is a natural for technical positions of this nature. She has a BA in chemistry from the Western College for Women in Oxford, Ohio, and did graduate work in analytical chemistry at Ohio State University.

After service in the WAVES as a

Elizabeth Walkey

technical writer for the Bureau of Aeronautics and information officer for the Secretary of the Navy, Betty became chemist-librarian for the Motion Picture Research Council in Hollywood, where she was co-inventor of wallpaper peel paste that now is used by many movie studios.

Of her job as librarian at CEC, an electronic instrument company that finds a major market in the chemical, petrochemical and petroleum industries, Betty says, "Tracking down facts is fascinating when you can see the results in research and engineering progress and are aware that indirectly you are contributing to the creation of new products."

Betty believes that women, with their "natural curiosity, intuition and ability to handle details," have a bright future in technical and special library work.

There's one thing you'll be able to say for these professional women. They'll never be lacking in names for their pets. Take Betty's kitten, for instance. Its name: "Polytetrafluoroethylene."

District Landman

Gloria Patton Knox was the first woman to become an active member of the National Oil Scouts & Landmen's Association in 1940.

As district landman for American Republics Corporation in South Louisiana, Mrs. M. H. Knox calls Lafayette her home. Since her husband is district landman for Kirby Petroleum Company in Louisiana, a unique situation exists in their home. She claims, however, that they have had only one lease-play conflict, and then they really fought for the leases. Both of them came out with their share, "but it was a very silent household during this period."

Finishing high school at Shreveport at the age of 15, Gloria enrolled in business college instead of taking a teacher's course as her family wished. Before completing business school, she went to work for The Texas Company in 1923, where she was the youngest of 4 girls and 200 men. She acquired the nickname "Gloria" because of her hair. Her maiden name was really Carolea Hayes, but today only her immediate family and friends know her first name isn't Gloria.

In 1925, Gloria married J. A. Patton, gas superintendent for The Texas Company in Arkansas, and they went to El Dorado to live. It was during the boom, and she recalls many times witnessing whole teams disappearing in the mud holes in the main streets. But she says only the old timers remember or believe such stories. While in El Dorado, she worked for McMillan, Fehlman and Oliver Pipeline Company handling tank car shipments. This job was interesting, especially the time she filled a clean car with Nevada Crude and routed it East in a snow storm. When it arrived at its destination, it had to be dismantled in order to unload the crude!

Soon after the birth of their son, Bill, in 1927, the Pattons were transferred to Shreveport, where Gloria got a job with American Republics Corporation (then Federal Petroleum Company). Her employer, E. J. Raish, encouraged her to study contract law and drafting in night classes at Centenary College, which she did for about two years. It

Gloria Knox and grandson, David Patton

was not long until she was doing most of the scouting. Those were the pioneer days, and Gloria scouted wells from derrick floors and knocked on "farmer Brown's" door to lease his land.

Like all oil families, the Pattons kept on the move until 1936, when they settled in Lafayette. Gloria became district scout that year and two years later was made district landman for South Louisiana, Mississippi, Alabama, Georgia and Florida. With the increased activity in each state, her district was divided in 1944, and she retained only South Louisiana.

Her husband died in 1946, and Gloria later married H. H. Knox.

Since World War II Mrs. Knox has been turning her talents to directing the Carnival Ball each year for Lafayette. Her newest hobby is her grandson, David Patton, who will soon be four years old.

Women Engineers

Although women did not enter the engineering field before the 20th Century, they have become more interested in this field since World War II.

General increases in working women, of course, has something to do with the larger numbers going into engineering fields.

There are today some 4000 women engineers among the estimated 600,000 in the United States. A professional group was formed in 1952 called Society of Women Engineers with its first president Beatrice Hicks, vice president and chief engineer of Newark Control Company.

The chief drawback to employing women engineers is the same as in other Management level positions—women do not stay on the job. They will marry and leave.

It is interesting though that several grandmothers are employed, the most famous being Mrs. Lillian Gilbreth ("Cheaper by the Dozen" best seller) who had a dozen children and, now in her 70's urges young women to go into engineering.

PERSONALS

Joseph H. Corbin has been elected president of the Seaboard Oil and Gas Company. The new president succeeds his father, **Floyd H. Corbin,** who was one of the original incorporators of the oil production and development firm. Joseph Corbin is a graduate petroleum engineer of the University of Texas and a life member of IPAA and Colorado Mining Association.

George H. Shaw, George H. Hill Jr., A. P. Frame and **Charles S. Mitchell,** all members of the board of directors, have been appointed vice presidents of Cities Service Company.

In addition, **Paul Hodges** was named to the newly created post of assistant to the chairman of the board, and **Tom DeBow** was promoted to the position of director of advertising and news to coordinate all advertising, promotion, news, radio and television activities of the company.

Shaw is industrial relations counsel of Cities Service and has been a member of the board of directors since 1936. He received his BA and LLB degrees from the University of Colorado. Hill has been associated with Cities Service since 1945 and a director of the parent Cities Service Company since 1953. He is also a vice president and director of several Cities Service foreign and domestic subsidiaries. He was graduated from the University of Mississippi. Frame, in charge of Cities Service manufacturing, research and petrochemical activities, has been associated with Cities Service for 31 years and a member of the board of directors for the past year. He is president and director of Cities Service Research and Development Company and a vice president of several other Cities Service subsidiaries. A native of Nova Scotia, Frame was graduated from Dalhousie University, Halifax, Nova Scotia. Mitchell has been associated with Cities Service for 25 years in various capacities and since 1955 has been manager of transportation and crude oil supply for the Cities Service system.

Hodges received his education at Oberlin College. He was associated in Cities Service with the late Merle Thorpe from 1947 until Thorpe's death last November. DeBow has been associated with Cities Service for 30 years. He was formerly manager of the advertising and news department of Cities Service Petroleum, Inc.

Henry J. Struth, petroleum consultant, has established new headquarters in Dallas, Texas. Following the recent publication of "World Petroleum Report," which he compiled and edited, Struth has announced an expansion program of activities, including international petroleum industry surveys, regional and national studies of oil and gas finding costs, government-industry relations, and a series of informational oil reports. He will serve also as economic advisor and consultant to various domestic and foreign clients.

John G. McLean has been elected a vice president of Continental Oil Company. He has been associated with Continental as a part time consultant since 1948 and during the past 18 months has served as assistant to the president while on leave of absence from Harvard Business School. In his new position, he will be in charge of coordinating and planning activities for Conoco and will continue to make his headquarters in Houston.

B. R. Jackson

M. Bridgeman

N. A. Gass

Lord Strathalmond, chairman of the board of directors of The British Petroleum Company, Ltd., plans to retire from his post as of March 31 (See "Petroleum Profile," page A-8.) It is the board's intention to appoint **Basil R. Jackson,** present deputy chairman, to be chairman and **Neville A. Gass,** to be deputy chairman as of April 1. **The Hon. Maurice Bridgeman** will be appointed as director to fill the vacancy on the board resulting from Lord Strathalmond's retirement.

Jackson, a barrister-at-law, became associated with the Anglo-Iranian Oil Company (the name was changed to The British Petroleum Company, Ltd., in 1954) in 1921. He was appointed a director in 1948 and returned to London from New York City to become a managing director in 1949, having spent up to that time some 15 years in the U.S.A. He has also visited Persia and other areas of the Middle East. Jackson was made deputy chairman in 1950. Gass completed his education at McGill University, Montreal, Canada. In 1919, he joined the former Anglo-Persian Oil Company and served in Persia until 1934, when he was transferred to the London office. He has been a managing director of the company since 1939. Bridgeman began his employment with the then Anglo-Persian Oil Company in 1926. He has seen company service in Persia and in New York.

Senator Charles E. Tooke Jr., Louisiana official representative on the Interstate Oil Compact Commission, has been named chairman of a special committee to coordinate the work of expansion of the library located in the IOCC headquarters office in Oklahoma City, Oklahoma. Senator Tooke has announced the plan, a long-range project, to provide eventually a clearing house of information concerning oil and gas conservation and related subjects, including an index of information available in other libraries and from other sources, as well as the books articles, and pamphlets located in the IOCC headquarters library.

Archie D. Gray has been elected counsel of Gulf Oil Corporation. In this position, he will succeed **David Proctor,** who resigned as general counsel but continues as a director, executive vice president, and a member of the top policy making committees, including the executive, finance and management committees. Gray has been associate general counsel since 1955. He was educated at Texas A&M College and the University of Texas, receiving his law degree from the latter institution. Gray became associated with Gulf's law department in Houston, Texas, in 1935. **L. H. Austin** has been appointed to the staff position of director, business analysis and market research for the domestic marketing department of Gulf Oil. In his new position, Austin will be responsible for the staff function of supervising market research, sales analysis and sales forecasting, cost and profit analysis, budgets, and prices for the marketing department. He received a BA in philosophy from Syracuse University. He joined Gulf in 1934 in the New York sales division in a secretarial capacity. He was transferred to the Pittsburgh, Pennsylvania, general office in 1947 and has engaged in sales analysis and commercial research for the company's marketing activities until the present.

Edward Francis Johnson, general counsel to Standard Oil Company (New Jersey), will serve as co-chairman with **John Noble Jr.,** assistant general counsel of Arabian-American Oil Company, in the petroleum division of The Legal Aid Society's 1956 fund-raising campaign. Johnson has been associated with Standard Oil since 1926. Noble has headed the society's petroleum division since 1953.

Three new members have been elected to the board of trustees of Illinois Institute of Technology. They are **Frank F. Elliott,** president of Crane Company and **Frank W. Jenks,** vice president, International Harvester Company, both of Chicago, Illinois, and **Leslie E. Simon,** major general, U.S. Army, retired, Niagara Falls, New York, new director of research and development for The Carborundum Company.

W. H. Cline, supervisor of office services in Houston, Texas, has retired from Shell Oil Company after nearly 34 years with the organization. Cline attended Washington University of St. Louis, Missouri. He joined Shell at Tulsa, Oklahoma, in 1922 and has worked in Houston since 1932.

Dr. Martin A. Elliott, research professor at Illinois Institute of Technology, has been appointed director of the Institute of Gas Technology. Dr. Elliott is a gas engineer who has been a professorial staff member of Illinois Tech's mechanical engineering department since 1952. He received bachelor and doctor of philosophy degrees in gas engineering from Johns Hopkins University, has done extensive research on the development of diesel engines, the production of synthetic liquid fuels from coal, explosives and ammunition components, and has authored many articles for technical journals.

W. H. Walshe

Frank C. Ware

Woollen H. Walshe has been named a vice president of California Commercial Company, wholly owned subsidiary of Standard Oil Company of California. He has assumed direction of the firm's Washington, D.C., offices. He succeeds **E. M. (Ned) Burnham,** who has retired after heading the company's Washington office since 1944. Walshe joined the Standard of California organization at New Orleans, Louisiana, in 1946 as an attorney for The California Company, also a Standard subsidiary, and was named general attorney of that company in 1951. He was graduated from Tulane University with an LLB degree.

Frank C. Ware has been appointed executive vice president of Aetna Oil Company to succeed **Dr. Clive M. Alexander,** who has retired. Aetna Oil is a division of Ashland Oil & Refining Company. Ware, who attended the University of Kentucky, has been associated with Ashland Oil & Refining Company since 1934. Ware went to Louisville, Kentucky, as division sales manager of Ashland Oil in 1949 and was promoted to regional sales manager in 1951. Dr. Alexander, Louisville, associated with Aetna Oil for the past 25 years, has been a director and vice president since 1939 and became executive vice president in 1951. He began with Aetna as a consultant.

Dr. Clark R. Miller and **John R. Rock** have been promoted to newly created positions on Tide Water Associated Oil Company's executive staff in San Francisco, California. Dr. Miller, former western division medical supervisor, has been appointed medical director of the company. Rock will serve as assistant to the employee relations manager, with supervision over the company's employee training activities. Until recently, he was assistant western division employee relations supervisor. Dr. Miller joined Tide Water in 1950. He was educated at the University of Washington, the University of Maryland and George Washington School of Medicine. Rock came to Tide Water in 1954 as training supervisor at its Avon Flying A Refinery. He was graduated from the University of California and attended the Stanford School of Business Administration.

Herman L. Boyle, director of industrial relations, is being promoted to manager of organization department, a new department of Standard Oil Company (Indiana). The industrial relations department will be re-named the employee relations department. New director of employee relations will be **J. Howell Turner,** who is presently director of employee relations of the California & Hawaiian Sugar Refining Corporation. These changes will be made effective April 1. Boyle began service with the company in 1927 as traveling auditor. He received a Bachelor of Science degree from Indiana State Teachers College and a Master of Arts degree from Columbia University, after which he pursued other graduate studies at New York University. Turner was graduated from Stanford University and Stanford Graduate School of Business Administration.

Creole Petroleum Corporation has announced several recent personnel changes. **E. R. Adams** of New Jersey has been appointed head of the insurance section, treasurer's department, in Caracas, Venezuela. **C. C. Irvine** has accepted a position as administrative assistant manager of the industrial relations department of the Consortium Companies in Iran. **H. J. O'Malley** of New York City has been named manager of the law department in Caracas. He replaces **N. J. Campbell,** who has been elected vice president of Creole in New York. New supervisor of the training section in La Salina, western Venezuela, is **Ben Purdy.** He recently arrived there from the United States.

Richard C. Parish has been promoted to assistant manager of the contract bureau of General Petroleum Corporation.

Frank J. Karmelich, formerly with Westates Petroleum Corporation, has been appointed to the engineering staff of the Sunset Oil Company.

R. E. L. Batts, who has been division attorney at Fort Worth, Texas, for Gulf Oil Corporation, has retired after serving with Gulf since 1919. Succeeding him is **David W. Stephens. Joseph H. Ranson,** member of Gulf's legal staff in Houston, Texas, has also retired. He had been associated with the company for 22 years.

John J. Dorgan, Casper, Wyoming, has been promoted to the newly created position of director of credit and insurance for Continental Oil. A member of Conoco's Rocky Mountain region land staff for the past two years, Dorgan will make his new headquarters in Houston, Texas. He received his master's degree from the Harvard Graduate School of Business.

Arthur Thad Smith, Continental Oil Company, has been elected president of the board of trustees of the Rocky Mountain Mineral Law Foundation, Boulder, Colorado. Other officers are **William J. Wehrli,** Rocky Mountain Oil & Gas Association, vice president; **Clyde O. Martz,** professor of law at the University of Colorado, executive secretary, and **Howard Gullickson,** Shell Oil Company, treasurer.

Frank M. Ritchie of Houma, Louisiana, has been elected a member of the board of directors of The Louisiana Land and Exploration Company.

A. C. Fischofer has been appointed vice president and elected to the board of directors of Tropical Gas Company, Inc., Miami, Florida. Fischofer has retired as executive vice president and member of the board of directors of Esso Standard Oil, S. A. after more than 30 years of service with domestic and foreign affiliates of Standard Oil Company (New Jersey). In his last position, he was concerned with marketing, refining, and exploration in the Caribbean area and Central America, with headquarters in Havana, Cuba. Tropical Gas company with its international headquarters in Miami, Florida, now operates in 16 foreign countries, the company reported.

H. S. Skinner

J. L. Raglin

Harold S. Skinner has been promoted to associate general counsel for Continental Oil Company, specializing in government relations. He was formerly administrative assistant to the president. **John L. Raglin,** previously director of the employee communications division, industrial relations department, will succeed Skinner. Skinner joined Conoco in 1948 as an attorney at Ponca City, Oklahoma. He received his law degree from the University of Oklahoma. Raglin became associated with Conoco's industrial relations department in 1951 as editor of employee publications. He received his bachelor's degree from the University of Missouri, where he majored in journalism.

Serge B. Jurenev has been promoted to assistant to the president and chief economist for Continental Oil. Formerly assistant to the chairman of the board of directors, Jurenev joined Continental in New York City in 1942. Born in Russia, Jurenev studied mechanical engineering at the Imperial Institute of Technology in Russia and received his bachelor's degree from the University of Prague in Czechoslovakia. He also holds a master's degree in business administration from Dartmouth College.

Theo A. Morgan, director of conservation for the Kansas Corporation Commission, plans to retire from his post on March 1. He was appointed oil and gas mediator by former Kansas Gov. Alf Landon in 1934 and was responsible for setting up the present department. With the exception of about two years, Morgan has served in the same capacity since that time.

DEATHS

Professor A. O. Rankine, OBE, DSc, FRS, emeritus professor of physics in the Imperial College of Science and Technology, London, England, died in London recently at the age of 74. In 1927, he became interested in the subject of applied geophysics, especially in relation to the search for oil, and became advisor on such matters to the Anglo-Persian Oil Company (now the British Petroleum Company, Ltd.). He was made chief physicist of the company in 1937. At the end of 1947 Professor Rankine retired, but continued to act in an advisory capacity until his health broke down some three years ago.

W. H. Bryant, 81, independent oil man of Nocona, Texas, and Jonesboro, Arkansas, was killed January 20 in an automibile collision near Nocona. He was one of those who pioneered the Burkburnett field near Wichita Falls, Texas.

W. M. Gaston, 59-year-old vice president of North American Geophysical Company, died February 4, in a hospital at Houston, Texas. He had been ill for the past six months. Gaston had been in the oil business in Houston for the last 30 years.

OIL and GAS TRADE NEWS

New Rockwell Plant.

Rockwell Buys Plant

Rockwell Manufacturing Company has announced its purchase of a new 106,000 sq ft plant at Statesboro, Georgia, from General Instrument Corporation of Elizabeth, New Jersey.

The new plant — a one-story aluminum-sheathed steel-and-concrete building — will be used to manufacture a variety of Rockwell meter, valve and other products.

Located on a 33-acre plot, the building includes 80,000 sq ft of manufacturing space and 26,000 sq ft of office and service areas. It is completely air-conditioned.

McKee Awards Building Contract

Arthur G. McKee & Company has awarded a contract to construct a two-story building in Cleveland, Ohio, to the Albert M. Higley Company of Cleveland.

The new building, which will contain approximately 25,000 sq ft of floor space initially and will cost about $500,000 is expected to be completed and occupied by the McKee Company sometime in August. Work was started on the new building in January.

Present McKee home office and engineering headquarters are directly in back of the 74,000 sq ft of land purchased last September and on which the new building is being constructed. McKee at present has 84,000 sq ft of floor space at its home office, and the new building will increase this by about 30 per cent.

Provision is made for the future construction of two additional stories and the installation of passenger elevator service. The new building will be fully air conditioned with a central year-round system.

Davison Plans New Research Lab

The expanding research activities of the Davison Chemical Company Division of W. R. Grace & Company will be housed in a new laboratory near Baltimore, Maryland, scheduled for completion in 1956.

Approximately 52,000 sq ft in total area, the three-story building will provide for a staff of 160, including professional and supporting personnel. The 148-acre site was selected for maximum convenience about midway between Baltimore and Washington, D. C.

Present Davison research activities are largely centered at the division's Curtis Bay Works in Baltimore. Process engineering research will continue at Curtis Bay, while other departments that will be transferred to the new laboratory include research management, chemical research, agricultural research, catalyst research, nuclear research and new products development.

Consolidated Engineering Corporation of Baltimore has the building contract.

Dresser Expands in England

Dresser Industries, Inc. has obtained controlling interest in Edeco Rock Bits, Ltd., of Manchester, England. Dresser's British associates in the venture are the English Steel Corporation, the other principal shareholder, and the English Drilling Equipment Company.

By means of interchange of engineering and manufacturing information with Dresser's U. S. subsidiary, Security Engineering, Dallas, Texas, drilling bits and related products produced at Manchester will be identical with those produced for the American market. The new British enterprise, to be known as Security Rock Bits, Ltd., will remain under British management with F. Pickworth, chairman of the English Steel Corporation, as chairman. Its production facilities will be considerably expanded. Sales and services will continue to be handled by the English Drilling Equipment Company in close cooperation with Security.

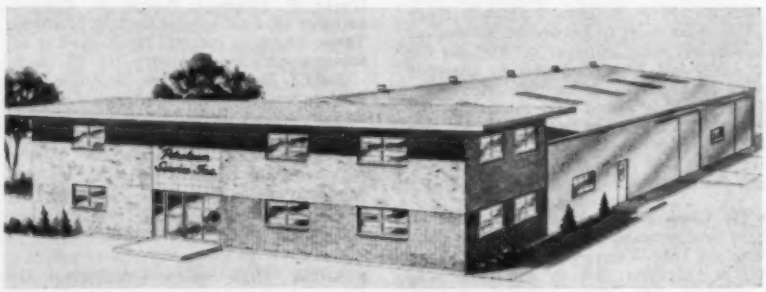
An agreement has also been reached with Ruston & Hornsby, Ltd., of Lincoln, England, for the manufacture and sale by Dresser in the U.S.A. of the Markta gas turbine, which develops about 1300 hp.

New Wire-Line Service Company

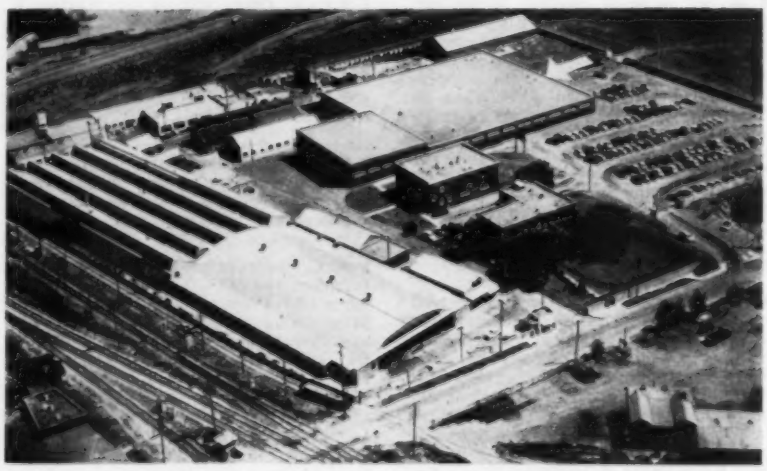
A new wire-line service company began operations in the Gulf Coast region late in February when the Great Lakes Petroleum Services, Inc., opened the doors of a new building in Houston, Texas.

The Great Lakes plant will include administrative offices, electronic laboratories, equipment proving areas, and shop facilities for design and assembly of wire-line tools.

Headed by "Red" Hancock, Jr., the new company is a subsidiary of the Great Lakes Carbon Corporation, of New York. Robert W. Smith is vice president and sales manager. Supervising the development program, which began last November, in temporary laboratories, is L. W. Toelke.



Headquarters for wire-line service company.



Increased working area will be realized in two new plant buildings of The Guiberson Corporation, Dallas, Texas. Construction has started on an oil field equipment manufacturing plant, shown by arrow in photo, and a rubber plant to be completed late in 1956.

Escambia Plans PVC Plant

Escambia Bay Chemical Corporation has awarded a contract to the Blaw-Knox Company for the construction of a polyvinyl chloride resin plant near Pensacola, Florida.

The new multi-million dollar facility will have a capacity of 30,000,000 lb per year. It marks Escambia's initial entry into the resin business.

The contract for the new modern resin plant will be executed by Blaw-Knox Company's chemical plants division, which will handle engineering, procurement, and construction on a turnkey project basis. Completion is expected late in 1956.

This plant will provide a complete line of suspension-type easy-processing PVC resins for electrical, sheeting, extrusion, and film uses. Production of Escambia's PVC resins will be under the supervision of Joseph Gafford.

Cook Service Group Formed

Cook Research Laboratories, a division of Cook Electric Company, has announced the establishment, within the laboratory, of a new, separate service group, a computing and data reduction facility.

Distribution Agreement Signed

The first national distribution agreement between an aluminum producer and a major oil country distributor has been concluded by Reynolds Metals Company and The National Supply Company.

National Supply will market Reynolds aluminum oil country pipe and will also stock aluminum couplers and fittings enabling its stores to supply complete aluminum pipe line systems.

Product Lines and Sales Merge

The United States Gasket Company and The Belmont Packing and Rubber Company have announced a consolidation of their product lines, sales organizations and activities under the merchandising name of U. S. Gasket-Belmont Packing.

Harry Stott, who headed sales for United States Gasket Company, is general sales manager of the new combination.

Mexican Subsidiary Established

Formation of a Mexican subsidiary has been announced by The National Supply Company.

Known as The National Supply Company of Mexico, S. A., the subsidiary will have its headquarters in Mexico City. The Mexican company will be managed locally by two vice presidents, Edward M. Gretzler and J. M. Estrop.

The Mexican organization was formed to provide better service on National Supply equipment used by customers in that country, which has become increasingly active in drilling and oil production. Sales to customers in Mexico will continue to be handled by National Supply's export division, with headquarters in New York City.

Gretzler, who began work for National Supply in 1919, has also seen service in Roumania and as vice president in charge of export sales of the National Supply Export Corporation. He became sales manager of the export division when it replaced the export corporation in 1952.

Estrop, a native of Mexico, worked for National Supply in the old Tampico days of the 1920's. Since 1948, he has been the representative for Mexico.

ARMSTRONG BROS.
Better PIPE TOOLS

CHAIN TONGS

"Reversible," "Standard" and "Ideal" types in all sizes. Jaws are drop forged from special steel, are carefully milled, heat treated, hardened and tested. The *Handles* are forged spring steel. The *Chains* are proof-tested to ⅔ catalog strength (1,200 lb. to 400,000 lb.) "Reversible" Jaws give double jaw life. "Standard" Jaws have extra bearing on the handle and forged-in chain guides. The "Ideal" Tongs have V shaped teeth for a sure grip on irregular shapes — fittings, etc.

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"The Tool Holder People"
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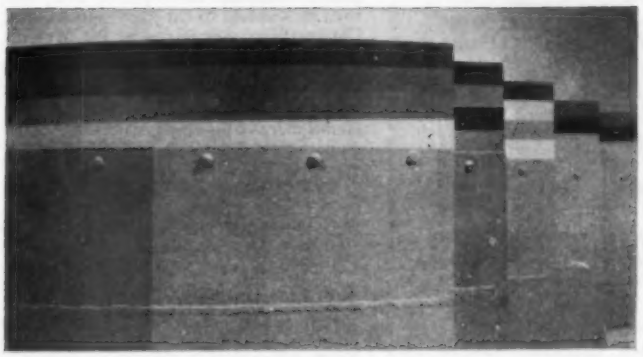
NOW AVAILABLE FROM GLIDDEN: Job-tested, anti-corrosive

PAINT FINISHING SYSTEMS



Typical Paint Finishing Systems: Here are a few of the Glidden Finishing Systems showing the step-by-step application of primers, intermediate and finishing coats. Glidden has a field-tested finishing system that will give you maximum protection against any corrosive or climatic condition.

Glidden job-tested finishing systems offer you the most durable, anti-corrosive protection available. Two developments make possible a special system for every type of corrosion problem and every climatic condition.

1. New highly anti-corrosive finishes that utilize the new Vinyls and NU-PON (epoxy) coatings. They have excellent chemical resistance and are outstanding for hardness, toughness and adhesion.

2. Field-tested finishing systems that take the guesswork out of buying anti-corrosive finishes. You get the right number of coats and the right finishes for every condition. You don't have to use four or five coats when two will do, and you don't have to use expensive anti-corrosive paints when they are not required.

For complete information on Glidden Paint Finishing Systems visit

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Professional Finishes

The Glidden Company
Maintenance Finishes Division
Cleveland 2, Ohio

Trade News

World's Smallest "Atom Smasher"

Radioactivity well logging was pushed several strides closer to positive identification and location of oil-bearing formations recently by the first successful test of the world's smallest "atom smasher" by Well Surveys, Inc., Tulsa, Oklahoma.

Perfection of this miniature high-energy source by Well Surveys, an affiliate of Lane-Wells Company, one of the Dresser Industries, is one step in the application of atomic energy to oil field problems begun by the company nearly 20 years ago.

Incorporated in a standard 3⅜ in. well logging assembly, this neutron generator is itself only 3 in. in diameter and 47 in. long, yet has been developed what is claimed to be the most intensive beam of neutrons ever used in a well. The device actually is a miniature version of a Van de Fraff particle accelerator.

The miniature Van de Graaff generates electrical potentials up to 200,000 volts.

New Canadian Company

A new firm has been formed to serve the needs of the operators in Saskatchewan and Manitoba, Petroleum Industry Services, Ltd.

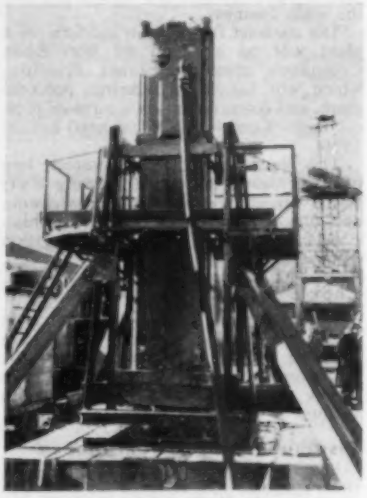
This new firm is headed by Ken R. Burns, and two directors, Ken R. Burns and Jayne S. Burns, have been selected. Other officers are Harry T. Carmichael, vice president and business manager, and Marie Wrana, secretary and treasurer.

The new firm offers all services and equipment as formerly performed by Bennett-Burns Engineering & Equipment, Ltd., the latter firm being currently dissolved.

World's Most Powerful Hammer

What is claimed to be the world's most powerful pile hammer has been constructed by the McKiernan-Terry Corporation of Dover and Harrison, New Jersey.

This hammer was designed and built for Brown & Root, Houston, Texas, ma-



rine contractors, a leading firm in the construction of "Texas Towers," the oil drilling platforms in the Gulf Tidelands. As the tidelands exploration programs move further out from the shore, the piles securing the towers to the ocean beds must be driven through deeper water into the ocean floor. The new pile hammer was designed specially for this service.

The hammer, 3 ft square and 15 ft high, weighs 20 tons and has a 10-ton ram. It delivers 60 blows a minute with a force of 60,000 ft-lb. It is driven by steam fed through a 3-in. hose from a 150-hp boiler delivering steam at a pressure of 150 psi.

New Cleaver-Brooks Corporation

A newly formed corporation, Cleaver-Brooks Western Hemisphere, Ltd., has been established to expedite marketing of Cleaver-Brooks products in the Western Hemisphere.

The new corporation will render improved service on Cleaver-Brooks products to all countries in the Western Hemisphere, with emphasis on the Canadian, South American and West Indies' markets.

R. P. Honnold, newly appointed vice president in charge of the corporation, will continue as export manager of Cleaver-Brooks Company, the parent company.

Joy Sets Up New Division

Joy Manufacturing Company has launched a new facility at Buffalo, New York, which is to be known as its turbodynamics division.

The Buffalo organization's objective is the establishment of a major new division producing advanced compressors, turbines, and other air and gas-handling devices. This new research and testing facility will point its activities toward laboratory development of prototypes and will establish designs for regular manufacture.

Head of the turbo-dynamic laboratory is L. Roy Krouse. John D. Russell is engineering vice president of Joy.

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feet of TK-2 coated tubing are in use!

TUBE-KOTE T.M. REG.

15,000,000 feet in use . . . twice as much as in 1954 . . . proof of TK-2 dependability in preventing oil field corrosion and paraffin troubles before they start.

Result: more oil companies *save* money by coating new and used tubing with TK-2 plastic before corrosion damage forces replacement.

Learn about TK-2 — why it is the lining companies specify for every major oil field, how it makes your first tubing cost your last, even in the most corrosive field. Write for new TK-2 literature.

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PIONEERS IN PLASTICS SINCE 1939

Manufacturers-Extruders of Plastic Pipe for the Oil Industry . . . Factory-trained Field Engineers available for Consultation in all Principal Oil Areas.

Williams, McWilliams Are Merged

Merger of two engineering and construction companies, McWilliams Dredging Company and W. Horace Williams Company, both of New Orleans, Louisiana, has been announced.

The combined organization will be known as the Williams-McWilliams Industries, Inc., and both the companies will remain as separate entities with no change in personnel, type of activities, management or offices and loading locations. Chief effect of the merger will be to increase vastly the scope of both companies through pooling of equipment and facilities. It also provides a substantially enhanced cash position for both. It is estimated that these advantages will enable the combined companies to exceed normally projected earnings in 1956 by more than 20 per cent over the combined earnings of each separately.

Cook Buys Acme Tool & Testing

R. M. Cook has purchased the patents and physical assets of the Acme Tool and Testing Company of Long Beach, California, and is now operating an oil well testing service under the name of Cook Testing Company.

The Cook Formation Tester was invented and placed on the market by Boyd McKinley of Acme Tool and Testing, who will continue his connection with this tester by remaining with Cook Testing.

Gardner-Denver Expands Work

Gardner-Denver Company has recently expanded its facilities for serving the petroleum industry, and has increased personnel in its oil field division.

The enlarged operations are headed by O. C. "Butch" Knapheide, who is now manager of Gardner-Denver's oil field division.

Caran Bros. Forms New Company

The Caran Engineering Corporation has been formed by the Caran Bros. interests in San Antonio, Texas, to consolidate the services offered by the Caran Bros. Engineering Company, International Exploration, Inc. and Hydrocarb, C. A. Activities of the new corporation, both domestic and foreign, will include mud logging, core analysis and reservoir engineering. A new and improved spectrochemical method for the quantitative measurement of hydrocarbon gases in the mud stream has been developed, and this new service will be available to the oil industry.

GE Widens Computer Activities

General Electric Company has actively entered the industrial computer field through a broadening of its computer activities from specialized engineering and military lines.

The move included integration of the company's widespread computer operations with the establishment of an industrial computer section at Electronics Park, headquarters of the G-E electronics division, Syracuse, New York.

Appointment of H. R. Oldfield Jr., as general manager of the industrial computer section also was announced. Oldfield was formerly manager of the G-E microwave laboratory at Stanford Industrial Park, Palo Alto, California. Other appointments include Kenneth R. Geiser as manager of engineering for the new section, Clair C. Lasher as manager of marketing, and George C. Trotter as manager of sales.

Dorr-Oliver Acquires Merco

Dorr-Oliver, Inc., has acquired all of the business and substantially all of the assets of Merco Centrifugal Company in exchange for approximately 50,000 shares of common stock of Dorr-Oliver, Inc.

Merco Centrifugal Company, with headquarters in San Francisco, California, has been engaged in the manufacture and sale, largely in the United States, of centrifugals, centrifugal screens and strainers. Similar equipment is not now manufactured nor sold by Dorr-Oliver, Inc.

Cash Purchases Farris Stacon

The A. W. Cash Company has purchased the business of the Farris Stacon Corporation, manufacturers of temperature control valves. The A. W. Cash Company manufacturers the Cash standard line of valves, controllers, governors and regulators. This new product line will be known as Cash Standard Stacon.

Operations of the Farris Stacon Corporation will be transferred to the Cash Decatur, Illinois, plant.

Continental Supply Now Division

The Youngstown Sheet and Tube Company has announced that the oil field supply business conducted by its wholly owned subsidiary, The Continental Supply Company, will now be operated as a division of the parent company.

This phase of Youngstown's operations will now be conducted under the name "Continental Supply Company, a division of The Youngstown Sheet and Tube Company." No change in personnel or in sales or operating policies is contemplated.

WISCONSIN-Powered UNIT

helps solve a difficult technical problem...

Today salt water disposal is becoming more and more of a problem among oil operators, due to stringent state regulations and a constantly growing interest in water conservation programs. Pollution of surface and shallow fresh water strata can lead to litigation, higher losses and damages.

The solution of this problem lies in drilling salt water disposal wells and pumping the brine, produced with the oil, back into the formation. A high pressure (1000 lbs.) Wisconsin-Powered pumping unit provides a practical and economical means for handling salt water. The application illustrated here shows a pumping unit connected to a salt water disposal well with 2" fittings and pressure gauge. Pumps are made of aluminum bronze, stainless steel, ceramic material, lead bronze, etc., in order to stand up under this varying type of service.

Dependable, all weather power is delivered by a Model VF4D and VG4D Wisconsin V-type, 4-cylinder, heavy-duty AIR-COOLED ENGINE, equipped with Stellite exhaust valves and valve seat inserts, positive type valve rotators, tapered roller main bearings and other features that assure trouble-free service and lowest cost maintenance.

You can't do better than to specify "WISCONSIN POWER" for your equipment.

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OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

Trade News

PGAC Safety Device in Free Use

Perforating Guns Atlas Corporation has announced the outright contribution by the company of an important safety patent to all companies now or hereafter licensed to operate under the jet process in the perforating of oil and gas wells.

PGAC engineers devised a completely new blasting cap assembly, combining a high-resistance element and a fuse in the circuit. This new cap cannot be detonated until after its fuse is burned away, and the fuse cannot be burned away by other than a relatively high current. Such current cannot be picked up accidentally by the circuit but must be introduced by the simultaneous closing of two electrical circuits, which, in turn, can be accomplished only by two hands simultaneously and intentionally operating two separate switches on the control panel.

In the interest of increased safety for the entire jet process perforating industry, PGAC is now granting to all present and future licensees having the right to use the jet process, the additional right to use this PGAC invention without the payment of royalty of any kind.

Excel Buys Instrument Line

Excel Electric Service Company has purchased rights to manufacture and distribute material level electronic control equipment formerly produced by the Gaydon Company, LaGrange, Illinois.

This will be the second instrument line to be produced by Excel's subsidiary manfacturing company, present producers of the Allen Ground Detector.

The product, previously identified as K-trol, will be distributed under the name of the Excel Proximity Relay.

'Siamese Twin' Ships Launched

A "Siamese-twin" ship launching was carried out recently at The Ingalls Shipbuilding Corporation shipyard at Pascagoula, Mississippi.

It was believed to be the first launching of its type in the history of shipbuild-

ing. Welded together especially for the launching resting on the same cradle, two supply vessels that will service oil rigs in the offshore gulf fields were christened at the same time and slid together into the Pascagoula River. Sea Service, Inc., owns and will operate the ships.

The twins, "Offshore Service and Gulf Service," are diesel-powered vessels 135 ft long with a 32-ft beam. Each will carry 500 tons of water or supplies to the drill barges off the coast. They were constructed in 54 days.

Development Center for Lummus

The Lummus Company will establish early in 1956 an engineering development center in Newark, New Jersey.

For this purpose, Lummus has purchased a 150,000 sq ft building on a ten and one-half acre plot near the Newark Airport.

Lummus, which has had similar facilities in Bayonne, New Jersey, for the past 25 years, will use the new building primarily for pilot plant operation and process development work carried out in conjunction with its clients.

Offshore Platforms Being Built

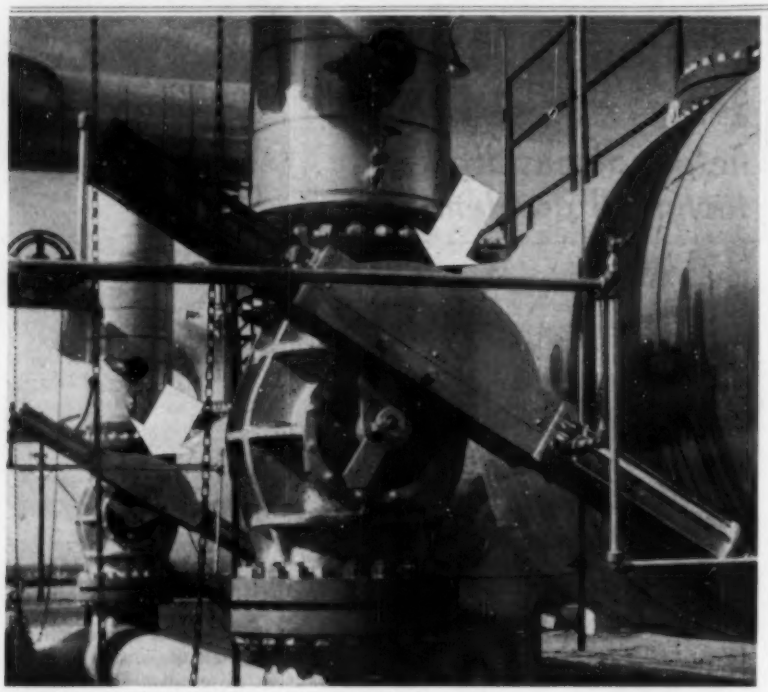
The American Bridge Division of U. S. Steel Corporation has launched the first of two giant offshore mobile drilling platforms being fabricated by the Orange, Texas, plant under a contract with the DeLong Corporation, New York City. The pair of big new structures will be owned and operated by The Offshore Company of Baton Rouge, Louisiana.

These new units each will be 200 ft long, 105 ft wide and 15 ft deep. Both will function in a fashion generally similar to those previously constructed by the U. S. Steel plant but incorporating radically different design in specific respects.

The unit is expected to be ready for movement to its first offshore location shortly after March 1. The second platform now under fabrication is scheduled for launching in about a month.

Both new platforms are designed for drilling in waters up to 100 ft deep. The new design replaces the tubular caissons of the previous unit with four-legged "towers." Each consists of two smaller tubular sections and two triangular built-up sections cross-braced to form one of eight such towers operating through as many "wells" in each barge.

Finished tower units will be 200 ft long and measure roughly 12 ft in diameter, with round and triangular sections located opposite each other.



(Unretouched photo of Ledeen Valve Actuators in operation)

AMINE RECOVERY PLANT PLUG VALVES OPERATED BY LEDEEN VALVE ACTUATORS

Natural gas companies find these operators safe, positive, dependable for automatic operations

Ledeen Valve Actuators are used in compressor stations on automatic blowdown valves, fuel shutoff valves, relief valves, pipeline and station block valves, and many more applications along with the Amine Recovery Plant installation shown.

These valve actuators are pneumatically and hydraulically operated, do not leak and are easily mounted by field personnel without modification of plug valve. They can be mounted in any position around the valve; and are available with auxiliary manual operation, either at valve or at a remote location. For preventive maintenance, actuator and control system can be operated without turning the valve. Torque ranges from 500 to 500,000 inch pounds.

WRITE FOR BULLETIN 3020

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AIR HYDRAULIC PUMPS & BOOSTERS

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Los Angeles 15, Cal.

TRADE PERSONALS

J. Tullis

M. R. Jones

John Tullis has been named general works manager for Unit Rig & Equipment Company. Formerly, he was technical staff assistant to the company president. **C. F. Southward** has been appointed administrative manager, sales department. His former position was district manager of the West Texas district.

Marvin R. Jones will head a newly formed department within the commercial products engineering division of Cameron Iron Works, Inc. The new department will conduct research and development work in connection with new products, as well as supervise the company's patent program. Jones' experience includes work with a number of tool companies. **Robert K. Le Rouax** will serve as research engineer. He has done product development work with several tool and supply companies.

James Whitaker and **B. R. Noel** have been appointed foreign representatives for Christensen Diamond Products Company. Whitaker will be the company representative in the Near East, making his headquarters in Beirut, Lebanon, while Noel will be the South American representative with headquarters in Caracas, Venezuela. They will work closely with R. J. Eiche and Associates, Inc. (export representatives) and will represent both Christensen Diamond Products Company and Christensen Diamond Products Company (France).

A. C. "Billy" Oden has returned to McEvoy Company after an absence of nearly 2 years. He has been appointed manager of McEvoy's export division and will also be in charge of the domestic agents who represent McEvoy throughout the United States. Oden has been in the oil field equipment business for 20 years.

W. J. Hegerty has been appointed vice president-sales of the Colonial Iron Works Company. For the past three years, Hegerty has been sales manager of the company and also on the board of directors.

Lee T. Ellis has been named manager of General Electric Company's mining and chemical systems sales unit, systems sales section. Ellis was graduated from Drexel Institute of Technology with a BS in electrical engineering in 1941, joining GE the same year. He was designated a sales engineer assigned to the petroleum industry at Philadelphia, Pennsylvania, in 1950, the position he held until this appointment.

William B. Ilko has been named administrative assistant to the vice president and director of sales for American Chain & Cable Company, Inc. He had been general sales manager of the Simonds Abrasive Company up to the time of his association with ACCO.

Kay Miller, formerly chief research and development engineer of Borg Warner Corporation, has been appointed assistant chief engineer of American Tractor Corporation. Miller was born and educated in Denmark, but came to this country in 1928.

E. J. Mercer

H. J. Schlarb

E. J. Mercer has been appointed general manager, construction machinery division, Allis-Chalmers Manufacturing Company. Mercer had been managing director of Allis-Chalmers Great Britain, Ltd., with headquarters at Essendine, England, since 1953.

H. J. Schlarb has joined Emsco Manufacturing Company as sales manager of the swivel joint division. Schlarb had been assistant sales manager for the Chiksan Company.

M. E. Swaim

H. T. Jarmon

M. E. Swaim has been made general manager of sales, a newly created position, by The National Supply Company. **Thomas B. Herndon** has been named to succeed Swaim as manager of oil field sales. Swaim has been general manager of oil field sales since 1954. Herndon had served as sales manager, production equipment, since 1954.

H. T. Jarmon has been named secretary-treasurer of Welex Jet Services, Inc. He was treasurer before assuming the new position.

William D. Smith has been made chief engineer for Welex. He was manager of the company's radio-activity logging department until he became chief engineer.

R. Neil Jones has been promoted to vice president of United Supply and Manufacturing Company. Jones has extensively covered oil field supply operations throughout the Mid-Continent and Gulf Coast areas for the company.

C. D. Haxby has been elected president of the National Constructors Association for 1956. Haxby, who is vice president of The Rust Engineering Company, succeeds **T. C. Williams,** president, Stone & Webster Engineering Corporation. **Carl B. Whyte,** president, Procon Incorporated, was elected vice president of the association. Chosen members of the executive committee were **Paul S. Klick Jr.,** Foster-Wheeler Corporation; **G. I. Seybold,** Chemical Construction Corporation, and **H. A. Denny,** Koppers Company.

Herbert E. Kingsbury has been appointed manager of product sales, centrifugal pump section, Allis-Chalmers Manufacturing Company's Norwood Works. Kingsbury joined Allis-Chalmers in 1943 after receiving his mechanical engineering degree from Marquette University.

E. D. Anderson and **E. W. Flaxbart** have been advanced within the management structure of the heat exchanger division of Western Supply Company. Anderson, who has served Western for the past seven years as chief engineer has been promoted to manager of the heat exchanger division. Flaxbart will assume the cheif engineer's responsibilities, vacating the post of chief rating engineer, which he has held for several years. Anderson holds a BS degree in chemical engineering from the University of Wisconsin. Flaxbart is a University of Tulsa graduate with a BS degree in petroleum engineering.

Kenneth H. Gayle Jr., has been elected president of Delta Tank Manufacturing Company, Inc. **Hal S. Phillips,** president of Delta since 1946, has been elevated to chairman of the board. Gayle had been president of Ingalls Iron Works Company, having joined the company in 1923.

A. Clark Daugherty, former market research manager of Rockwell Manufacturing Company, has been named assistant to the president. The market research, public relations and stockholder information departments will continue to report to Daugherty, who has also been assigned additional management functions.

K. R. Chandler has been made service manager for the Koehring Company, succeeding **G. N. Nelson,** who has retired after 44 years of service with Koehring. Since 1954, Chandler had been at the home office in Milwaukee, Wisconsin, in service department work.

Clifford N. Cox is now sales manager for Insul-Mastic Corporation of America. Prior to joining Insul-Mastic, Cox held the positions of sales manager and eastern division manager for D. A. Stuart Oil Company.

H. Lee Norris Jr. has joined Kinzbach Tool Company, Inc., as chief engineer. Norris spent the past five years as project engineer on gas pipe lines, compressor stations and gas processing plants for The Fish Engineering Corporation.

The Answer to Your SEALING PROBLEMS in the Palm of Your Hand

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Trade Personals

J. E. Sayers

T. L. Guarniere

James E. Sayers has become sales manager for the newly created northern sales region of Security Engineering Division, one of the Dresser Industries, Inc., overseeing Security's expanded Rocky Mountain and Canadian sales activities from headquarters in Denver, Colorado. Sayers was formerly Canadian division sales manager. Appointed to occupy Sayer's former post is **James R. Kelly** of Edmonton, Alberta, where he will have his headquarters. Kelly has been active in the drill bit business in Canada since 1951.

T. L. Guarniere has been made merchandising manager of the Detroit Diesel Engine Division of General Motors. While director of service training, he used mobile units to provide "on-the-job" training in the proper operation and maintenance of diesel units throughout the United States, Canada and Mexico and in various points in South America. Prior to his present appointment, Guarniere was sales promotion manager.

Robert F. Lay has been elected vice president and general sales manager of The Cooper-Bessemer Corporation. First associated with Cooper-Bessemer in 1924 as a co-op student at the University of Cincinnati, Lay later returned to Cooper-Bessemer in 1946, becoming sales manager last year.

A. T. (Robby) Robertson has been named personnel director of the Magnet Cove Barium Corporation. Prior to his present appointment, he was located in McAllen, Texas, as a field engineer for the company.

Dr. James Y. Oldshue has been advanced to the position of director of research, Mixing Equipment Company, Inc. Dr. Oldshue has been engaged in fundamental and applied research in fluid mixing since joining Mixing Equipment in 1950 and prior to his promotion, he served as head of development engineering. He received his BS, MS and Ph.D degrees from Illinois Institute of Technology.

Herbert E. Barth has been named to the newly created position of executive vice president of American Blower Corporation. **Edwin W. Petersen** was appointed vice president-sales succeeding Barth. Petersen formerly was sales manager of American Blower. Service with the company dates back to 1915 for Barth and to 1923 for Petersen.

Also announced were two executive appointments for Canadian Sirocco Company, Ltd., a subsidiary of American Blower. **Clarence W. Johnson,** formerly vice president and general manager of Canadian Sirocco, has become president and **Richard R. Noyes,** sales manager, was made vice president-sales.

J. A. Muller has been named technical manager of the rubber division of The Thermoid Company. He was formerly executive engineer of the industrial rubber products division.

John E. Duesing has been appointed sales manager of the mechanical division of Hagan Corporation, replacing **Gerald G. Lipke,** who was killed last November in an air crash in Colorado. Duesing had only recently been named general manager-sales of Dominion Flow Meter Company, Ltd., a subsidiary of Hagan Corporation.

Paul M. Myers has been appointed by Web Wilson Oil Tools, Inc., as a salesman in Oklahoma, with headquarters in Oklahoma City. He has had 21 years experience in the oil fields, and as salesman and manager for supply companies.

J. H. Newton has been named as sales manager of the White Diesel Engine Division of the White Motor Company. Newton has been associated with the heavy-duty diesel engines industry in sales for the past 19 years, since 1948 with White Diesel Engine Division sales activity.

W. A. Brown, Jr.

A. J. Weith

William A. Brown, Jr., has been appointed general manager of the alemite and instrument division of Stewart-Warner Corporation. Brown formerly was president of The Liquid Carbonic Corporation, having been associated with that company since 1935. Appointment of Brown as head of the alemite and instrument division of Stewart-Warner fills the vacancy created by the recent death of **Frank A. Hiter.**

Dr. A. J. Weith has been promoted to the position of sales manager of American Cyanamid Company's petrochemicals department, in the general offices, New York City. Dr. Weith had been assistant sales manager of petrochemicals.

Kenneth E. Quigg Jr. has been appointed a sales engineer for the Condit Company. Before joining Condit, he was associated with the controls division of Black, Sivalls & Bryson, Inc., for three years as application, field service and sales engineer.

Phil R. Becker has been named general manager of sales by Midwest Piping Company, Inc. Becker had served as sales manager of the company's welding fitting division.

J. G. Tuthill

J. P. Mansfield

James G. Tuthill has been elected president of Tuthill Pump Company, Chicago, Illinois, succeeding **H. T. Kessler,** who has retired from active service. Grandson of the founder of the company and son of the late chairman of the board, Tuthill was made vice president last year.

John P. Mansfield, Midland, Texas, has been promoted by The Western Company to assistant sales manager in charge of staff operations. He moved up from the position of assistant to the sales manager.

J. Lawrence Tecosky has been appointed vice president and contract manager for CDC Control Services, Inc. He was formerly secretary. **Jack C. Boonshaft** is CDC's new consulting mechanical development engineer. His previous position was vice president in charge of engineering with Fischer & Porter Company.

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MILTON J. FRAMPTON, Manager

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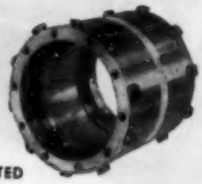

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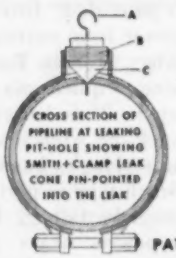

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Trade Personals

J. D. A. Morrow has retired as president of Joy Manufacturing Company to take over as chairman of the board. At the same time, **John Lawrence** has been advanced to president and chief executive officer; **W. L. Wearly** to executive vice president, and **H. C. Nyquist** to vice president, general sales. For the past year and a half, Lawrence had been executive vice president. Wearly for the last three years has been vice president, general sales. Nyquist had been vice president, coal machinery sales.

J. Robert Kelley has been elected president of Manning, Maxwell & Moore, Inc., succeeding **Hamilton Merrill,** who has retired after 35 years with the company. He will continue as a director and member of the executive committee. Kelley was formerly executive vice president.

DEATHS

Dr. S. D. Douglas, recently appointed senior scientist in the research department of Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation, died at Houston, Texas, January 15 after a long illness. He was one of the foremost research scientists in the field of plastics. Increased production of vinyl resins was made possible by his 17 years of study and development, providing materials for hundreds of peacetime applications and wartime strategic materials. The nation's most distinguished award for achievement in the plastics industry, the John Wesley Hyatt gold medal, was awarded to Dr. Douglas in 1944. Dr. Douglas joined Carbide and Carbon in 1926 after being graduated from Middlebury College and receiving both his MS and PhD in chemistry from the University of Pennsylvania.

Harold S. Kendall, 62, assistant to the president of The Dow Chemical Company since 1941, died at his home in Midland, Michigan, January 8, after a long illness. Associated with the company since 1917, Kendall at the time of his death was a member of the company's finance committee and secretary of the Midland division operating board. He was a director of Brazos Oil and Gas Company, a subsidiary, until its recent merger with Dow. He received a BS in science from Grove City College, Grove City, Pennsylvania, and a BS in chemical engineering from Case Institute of Technology, Cleveland.

E. D. (Gene) Morris, vice president and general manager of Crutcher-Rolfs-Cummings, Inc., died January 15, in a Houston, Texas, hospital after a brief illness. Morris had rejoined the C-R-C organization earlier this year. He was formerly with the company from 1944 until 1950, when he resigned. During his 14 years in the pipe line business, Morris had become well known in the industry and had wide experience in the manufacture and sale of pipe line equipment and supplies.

Albert Walter died January 28 at his home in Miami, Florida. When he retired in 1946 as chairman of the board of Stauffer Chemical Company, he had served the firm for 40 years. He commenced his career with Stauffer in 1906 as a mining engineer in charge of Stauffer's phosphate operations at Cokeville, Wyoming.

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SELECTIVE SKIP SHAKER engages automatically — speeds flow of aggregates and cement into the drum, can be set for shaking when skip is full, or partially empty. It is readily disengaged when no shaking action is needed.

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TILTED FLOW-LINE DISCHARGE CHUTE with easy toggle-lever control reaches far into drum, catches all concrete — pours complete batch in 7 seconds.

MULTIPLE V-BELT DRIVE, high-carbon steel drum with double-thick roller paths, reduction gears enclosed in oil, and antifriction bearings throughout all assure dependable, trouble-free performance with this Kwik-Mix heavy-duty 6-S mixer.

OPTIONAL 6-S EQUIPMENT: distribution spout, auxiliary hoist, water pump, Batchmeter. Other sizes: 3½-S to 16-S Dandie concrete mixers. Also: 10 and 15 cu. ft. Moto-Bugs® with hopper, platform, fork lift attachments. See Kwik-Mix distributor, or write.

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Trade Personals

Selden A. Stone has been named well drill sales manager by Bucyrus-Erie Company. He had been assistant drill sales manager with the firm since 1953. **L. B. Birckhead,** former drill sales manager will serve in an advisory capacity in connection with spudder sales. He will continue to be responsible for blast-hole drill sales.

Douglas Daffin, formerly with Otis Pressure Control, is chief wire line engineer in the engineering department of Camco, Inc. **Joe Henderson** is now supervising the manufacture of wire line trucks, and **Fred Schnars,** formerly with The Atlantic Refining Company, assists in the development of gas lift equipment and in reservoir engineering work.

Herbert E. Schmiel is the new chief engineer of the industrial hydraulics division of The Parker Appliance Company. Prior to joining Parker earlier in the year as assistant chief engineer of the division, Schmiel had been with Hydreco division of New York Air Brake Company, Cleveland, Ohio, for the past 15 years.

R. L. "Les" Waller has been named assistant general manager of Rodman Supply Company, Odessa, Texas. He was formerly vice president and assistant general manager of Empire Machinery Company in Odessa.

Don L. Douglass has been appointed to the newly created position of parts sales manager for The Thew Shovel Company. For the past several years, he has served as vice president in charge of distribution and services for Wayne cranes for the American Steel Dredge Company.

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BOOKS ★

Tentative Specifications for Corrosion-Resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes, *issued jointly by the American Welding Society, 33 West Thirty-ninth Street, New York 18, New York, and the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania. Pages, 13. Price, 40 cents.*

Eight new classes of electrodes have been added to the revised edition of this AWS phamphlet. The additions cover the recently developed electrodes which have widened the range of stainless steels, clad steels and dissimilar metals that can now be successfully welded. The new classes covered are: Two extra low carbon grades (E308ELC and E316ELC); two columbium grades (E309Cb and E310Cb); two molybdenum grades (E309Mo and E310Mo); and grades E312 and E318.

Details are given on test methods, weld metal composition requirements, standard sizes and lengths, packaging and color markings for identification. An appendix is provided to aid prospective users in selecting the electrode class best suited for them.

The Welding of Austenitic Chromium-Nickel Steel Piping and Tubing, *a committee report published by the American Welding Society, 33 West Thirty-ninth Street, New York 18, New York. Pages, 27. Price, $1.00.*

This Committee Report, issued recently by the AWS, is intended to serve as a guide so that difficulties in the welding of austenitic stainless steel may be avoided. Although these steels have been satisfactorily welded for many years, certain welding problems have been reported by industry.

This report is divided into seven sections wherein the major welding considerations are presented, followed by a discussion of the suitability of various stainless steel grades for welding pipe, suitable welding processes, the proper selection of filler metal, the role of the welded joint, proper pipe welding techniques and inspection methods.

A helpful group of tables list standard AISI, ACI and ASTM types of austenitic stainless steels and the correlation between these types. Of particular value is a table giving specific welding rod or electrode to be used for welding each type of stainless steel.

Twentieth Century Petroleum Statistics, 1955, *published by DeGolyer and MacNaughton, 5625 Daniels Avenue, Dallas, Texas. Pages, 174. Price $7.50.*

This is the eleventh volume of this handbook and includes reports, charts and statistics on the many phases of the industry. The information has been drawn from material of the American Petroleum Institute, American Gas Association, U. S. Bureau of Mines, as well as from various trade publications. Material has been classified by states, countries, product and information categories. Many of the charts and graphs have been presented in color.

The loose-leaf bound handbook was originally prepared in 1945 by the Office of the Director of Naval Petroleum and Oil Shale Reserves, Navy Department. By Navy request, the book has been published annually since that time, its content value and popularity to the oil fraternity increasing with each issue.

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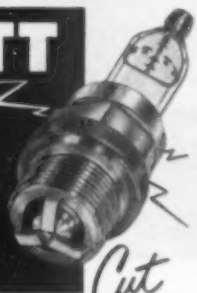

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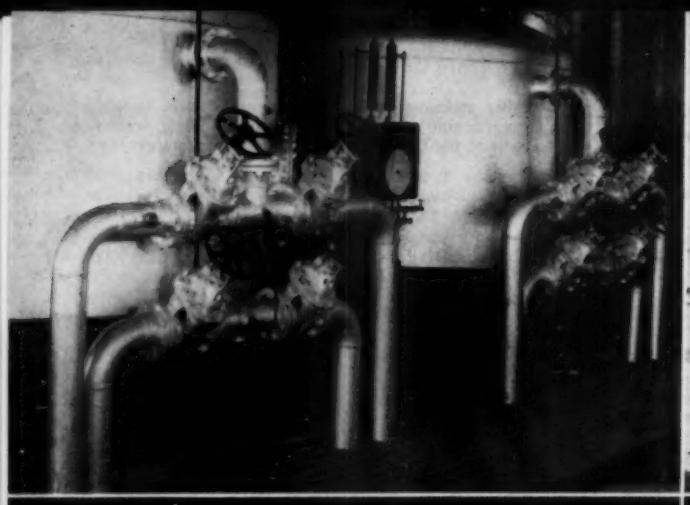

2-8′ x 5′ 40 PSI W.P. National Filters in Illinois Water Flood

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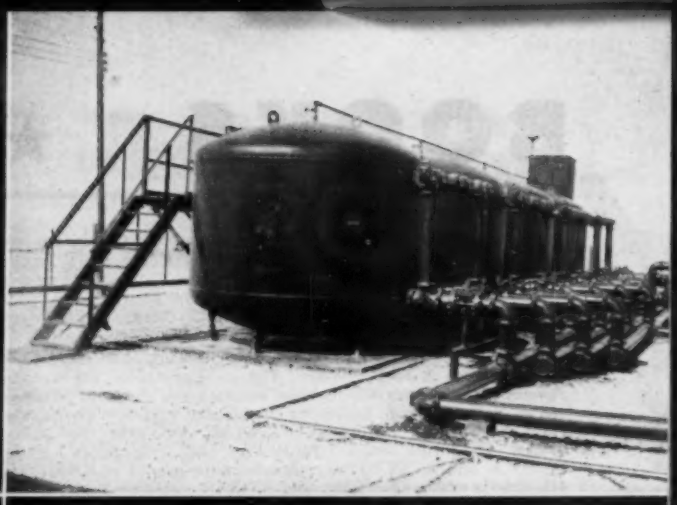
4-8′ x 5′ 60 PSI W.P. National Filters in gasoline plant near Schuler, Arkansas



8-75 PSI W.P. National Filters in Eastern Oklahoma Water Flood

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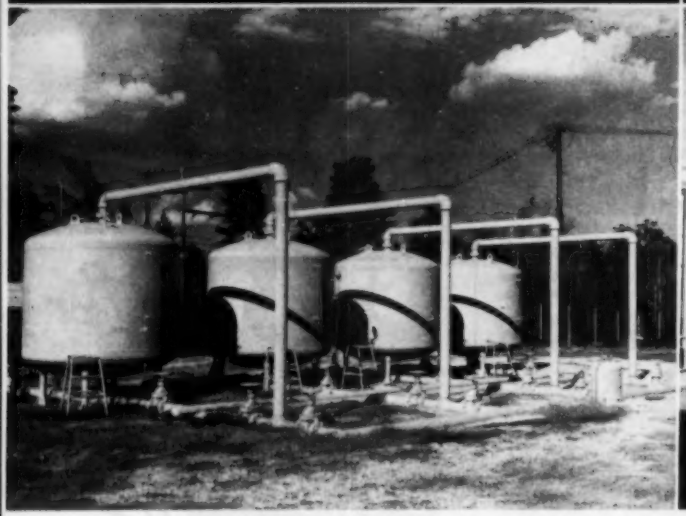
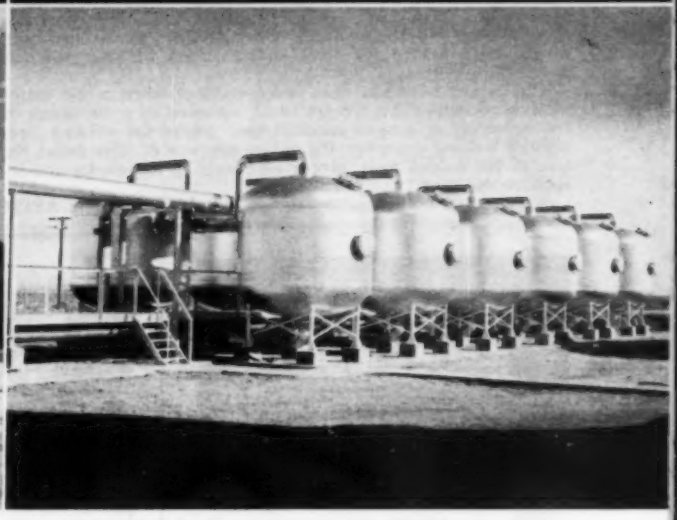
Battery of 200 PSI W.P. National Filters in West Texas Water Flood





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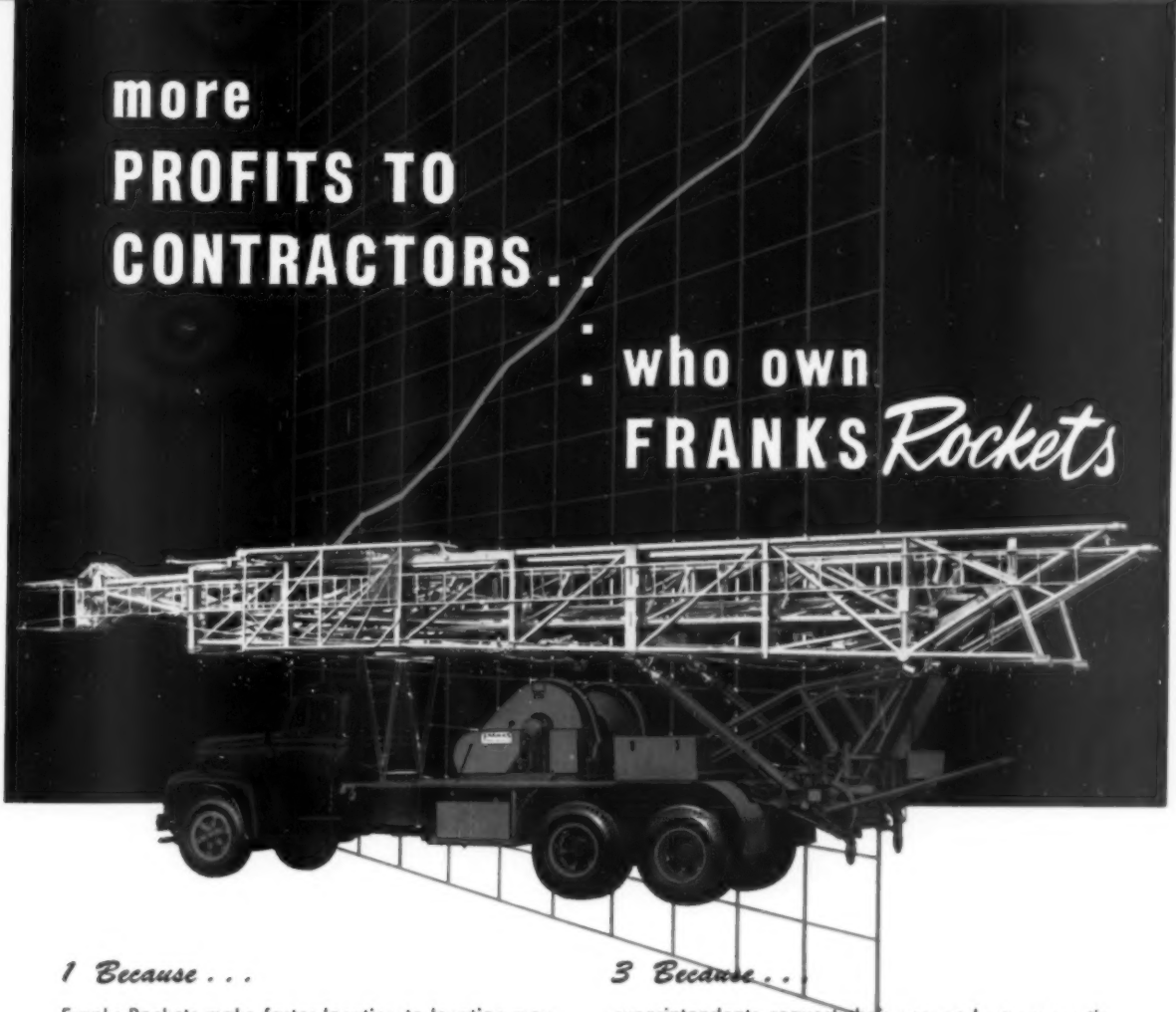

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2 Because . . .

Franks Rockets using air lift rod transfer actually pull rods and tubing faster and protects rods from excessive wear and tear.

Only Franks offers "on the spot" field service with stock of parts and factory-trained personnel at: Alice, Compton, Casper, Farmington, Great Bend, Houston, Kilgore, Odessa, Seminole, Edmonton and Tulsa.

3 Because . . .

superintendents request their use and consequently Franks units spend less idle time in yards.

IT WILL PAY YOU TO CHECK FRANKS ROCKETS BEFORE YOU BUY

FRANKS
DIVISION CABOT SHOPS INC
WELL SERVICING AND DRILLING UNITS
TULSA, OKLAHOMA

"ON THE SPOT" FIELD SERVICE

CABOT SHOPS, INC.

FRANKS DIVISION
Cabot Shops, Inc.
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Security

means RIGSIDE SERVICE

Our 25th Year Serving the Petroleum Industry

1. Pioneers in Rigside Service
2. Competent field engineering staff

Security **ENGINEERING DIVISION**
Plants: DALLAS, TEXAS • WHITTIER, CALIFORNIA
Export Office: Chanin Bldg., New York, N.Y.

ONE OF THE DRESSER INDUSTRIES

Of Things To Come . . . In Oil

SEARCH FOR GAS TO ACCELERATE as direct result of passage by Congress of the Harris-Fulbright bill. Many operators, especially the smaller ones, held off drilling up good gas prospects pending outcome of legislation. Situation is nation-wide. New spurt of activity would show up soon.

DRILLING ACTIVITY OFF in some areas as 1956 gets underway. February reports show Texas rig count down slightly, California down, Louisiana about the same, Rocky Mountain down. Some regions on upswing of a bigger year. West Texas shows increase in number of completions. Weather was big factor in many areas.

SHORTAGE OF TUBULAR GOODS IN OFFING and already being felt by some. Orders for line pipe now being taken by some mills for delivery as far ahead as 1958. Big pipe orders for second quarter are rolling in based on accelerated drilling program this year. Squeeze might be felt by mid-summer unless output stepped up.

NO CRUDE PRICE HIKE SEEN, in spite of vigorous efforts by numerous agencies and associations. Current excess domestic producing capacity — more supply than demand — when added to effect such hike would have on Washington reaction concerning pending oil and gas legislation (this is election year) are among arguments. Conoco president L. F. McCollum sees an increase within 12 months. however. On the other hand, Standard of Indiana Chairman Robert Wilson sees "no general increase."

HIGHER STEEL PRICES will come — on a piece-meal basis now, and across-the-board this summer. Present increases, say manufacturers, are to "get in line with production costs", while the summer hikes are expected with annual union contract renewals.

BIG PLAY IN RATON BASIN is foreseen this year. This rugged area is one of the few geological areas in the Rocky Mountains where oil and gas production has not yet been established. Several major companies and large independents have taken early commitments with a score of scattered wildcats showing some oil and gas.

SAVE 2 WAYS WITH

MARTIN RUBBER GUIDE CAGES

1. GREATER PRODUCING PROFITS *because:*

Martin Cages last much longer. The oil-proof rubber guides do the trick, by absorbing the ball peen hammer action of the hard balls. They also have superior resistance to sand abrasion. And they can be replaced.

2. GREATER PRODUCING PROFITS *because:*

Ball & Seat life is usually doubled, on the average. With the rubber guides, there is much less chattering, chipping and pitting. Ball falls true on seat. Such improvement in Ball & Seat life eliminates a lot of pulling expense.

In the last year alone, new users of Martin Cages have increased by 85%. The word is getting around. More and more economy-minded producers are learning about the advantages of the Martin Cages! . . . Manufactured in open and closed types . . . all diameters and styles. Write for John Martin Catalog No. 4 today. *Martin Cages are available through all supply stores.*

JOHN N. MARTIN

Manufacturer

9 W. BRADY • TULSA, OKLA.

Look TWICE

at your drill collar bargain!

Look ONCE

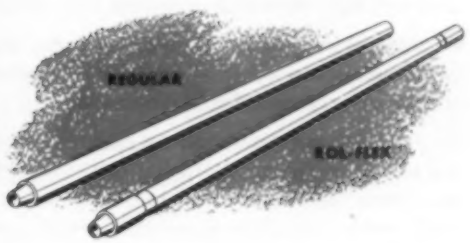
at the new drill collars on the rack. This is important for visual checks such as thread finish, smooth outside diameters and a smooth, straight bore. Most drill collars will have all of these features.

Now LOOK AGAIN

not at the drill collar, but at the manufacturer, his reputation in the drill collar business and the extras which he builds into his products. Are those "bargain" drill collars full-length heat treated? Made from quality, depth-hardened steel? Designed on sound engineering principles?

IT PAYS to look twice

before you invest in drill collars!



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PGAC KEEPS OPERATORS SMILING!

Now.. FIRST again

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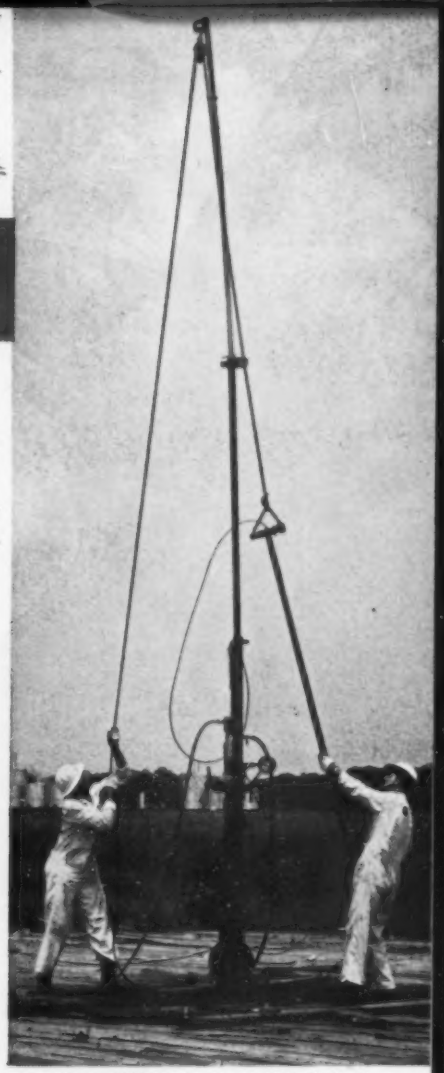
Remember....

PGAC—AND ONLY PGAC—GIVES YOU A SIMULTANEOUS GAMMA RAY and NEUTRON/NEUTRON LOG...ON A SINGLE TRIP IN THE HOLE!



PGAC-559

(Above) PGAC service crew preparing to lower new 1-11/16" Simultaneous Radiation Logging instrument through 2" tubing.

WHY USE 2 SEPARATE TOOLS REQUIRING 2 TRIPS IN THE HOLE?

- All of the superior logging standards of **calibration, stability** and **absence-of-drift**—for which operators have hailed PGAC's 3⅝" logging instrument for years—have been fully retained in this new 1 11/16" Simultaneous Radiation Logging Instrument now available for tubing completions.
- PGAC's Simultaneous Radiation Log is still the **only** Gamma Ray and Neutron/Neutron Log available. It utilizes a pure Neutron/Neutron to avoid the faulty phenomena of detrimental gamma rays inherent in all other "neutron" logs.
- **Moreover, PGAC *originated* and was the first company—*years before any other*—to deliver immediately in the field a simultaneously recorded radiation log.**
- Furthermore, PGAC has successfully logged and perforated the world's deepest (17,570 ft.) and hottest (349°F.) wells. Such know-how leads to PGAC's constantly improved instruments—tools without equal in accuracy, safety, operating speed and efficiency.

PGAC Simultaneous Radiation Log being recorded on instrument in field unit. Complete log is immediately delivered in field to operator.

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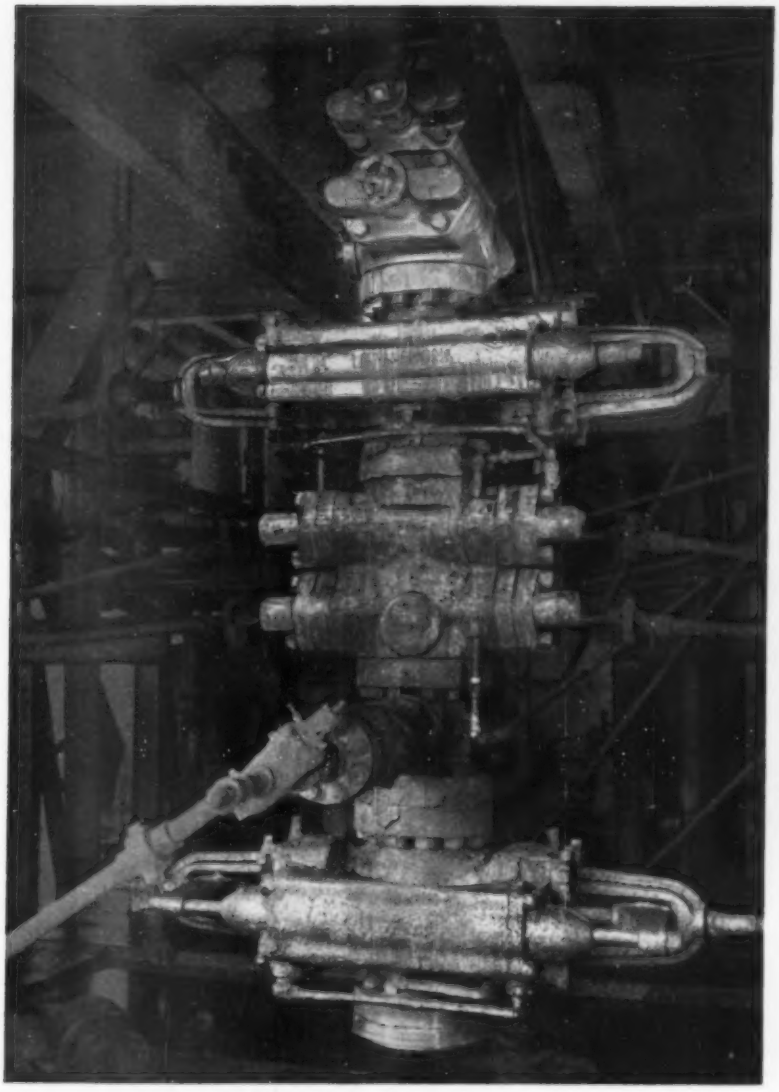
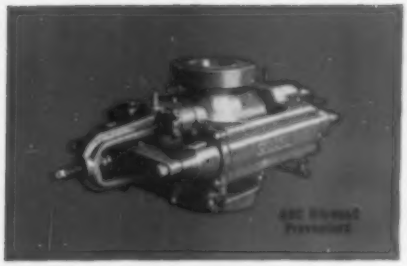
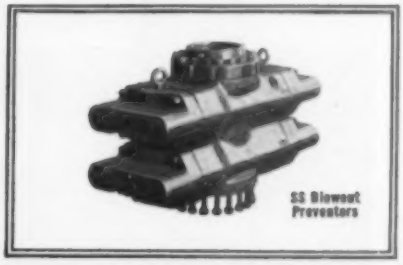
OKLAHOMA: Ardmore—Healdton—Oklahoma City—Pauls Valley—Perry—Seminole—Tulsa. NEW MEXICO: Hobbs.

AFFILIATE COMPANIES: CANADA—Perforating Guns of Canada, Ltd.; Edmonton, Alberta
GERMANY—Atlas Deutsch-Amerikanische Olfelddienst G. m. b. H.; Kiel VENEZUELA—Servicios Tecnicos Atlas, C.A., Caracas







WORLD'S DEEPEST WELL

WORLD'S BEST EQUIPMENT

Hearty Congratulations to:
Richardson and Bass, John W. Mecom and Freeport Sulphur. We are happy to have been a part of their remarkable accomplishment, the LL&E No. 1-L Humble, in the Lake Washington Field of Plaquemine Parish, Louisiana.

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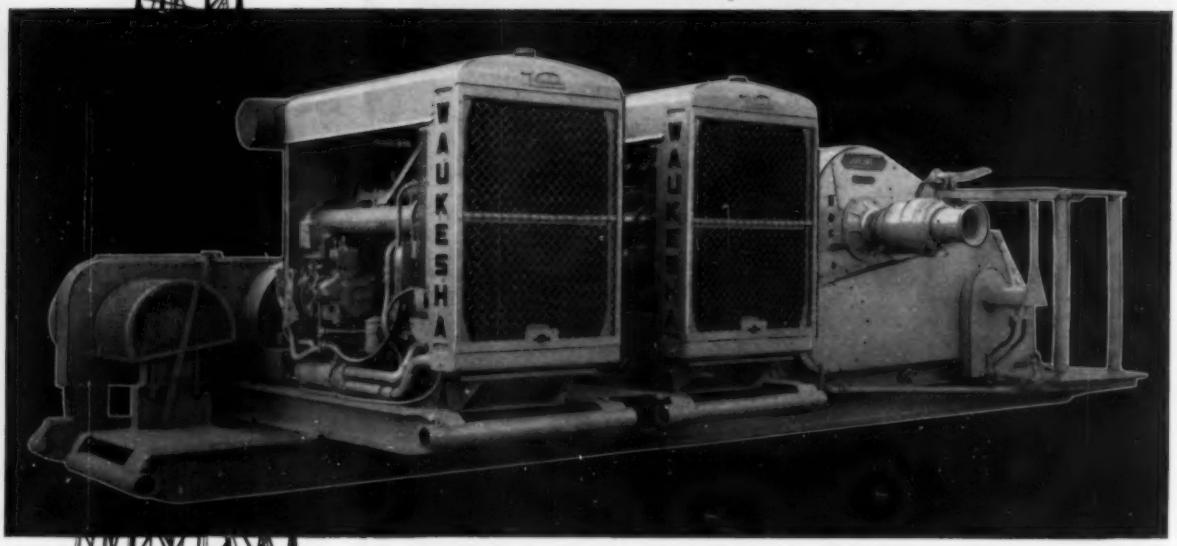
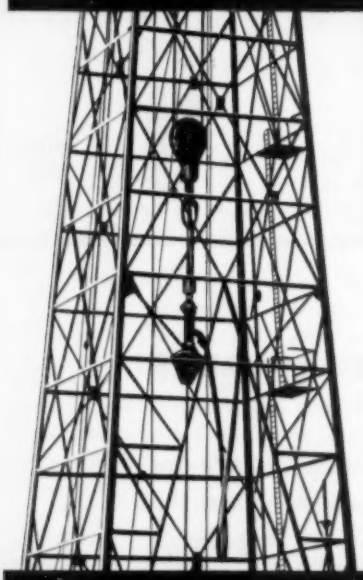
Twin WAUKESHA Units

power new CARDWELL draw works

Twin Waukesha WAKBU 1197 cubic inch Oil Field Special Gas Units power New Cardwell J-450 torque converter driven draw works





● With a normal workover range of 10,000-12,000 ft., a drilling range (4¼" pipe) of 4,500-6,000 ft., and rating of 450 nominal horsepower, the new Cardwell J-450 has the latest and finest drill rig design features. The power units shown here are Waukesha WAKBU High Output Oil Field Specials—each developing 250 max. hp at 1800 rpm on natural gas. They insure steady power under continuous duty load, and a lot more in reserve for emergencies. Their rugged, compact, overhead valve 1197 cu. in. engines, 6-cyl., 6¼-in. x 6½-in., have straight gas carburetor, regulator, water-cooled exhaust, aluminum pistons, counterbalanced crankshaft and vibration dampener. This new rig is also available with Waukesha WAK Series counterbalanced full Diesels. Send for WAK bulletins . . . gas or Diesel. 298

World's Finest Oil Field Power

WAUKESHA

50th ANNIVERSARY Waukesha MOTOR 1906-1956

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A FULL LINE OF 47 MODELS AND TYPES FROM 6000 IN. LBS. PEAK TORQUE TO 320,000 IN. LBS. A. P. I. — ALL

TOP QUALITY WITH THESE ADVANCED FEATURES

Screw type adjustable counterbalance with locking device and calibrations (one man may adjust with safety while standing on the ground). ... Forged steel gears---Helical or herringbone gear reducers.... Saddle provides four-way walking beam adjustment.... Bronze bushed long life saddle bearing.... Self aligning roller wrist pin bearings.... Tapered wrist pin cannot rotate in crank.... Internal expanding automotive type brake of ample capacity.... Over-the-beam equalizer.... Rugged, samson post and frame.... Adjustable horsehead may be swung back over the beam for well servicing.

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Foundry & Machine Works, Inc.
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THET'S ACCURATE SHOOTIN'!!
ONLY ONE GUY IN THESE PARTS, MO' ACCURATE THAN ME!!
THAT'S ME— ACCURATE JOHNSTON!!
AN' NOBODY'S MORE AVAILABLE THAN ME— AVAILABLE JOHNSTON!!
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NO MA'M—FO' TESTIN' OIL WELLS, WITH MINNYMUM DOWN TIME!!
WE IS ALLUS FAST, AS WELL AS ACCURATE!!
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first in drill stem testing

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Your drill stem dollars go further with "flash-weld"

Comparative oil field records show that you get economy and maximum drill stem dependability when you buy Hughes "Flash-Weld" tool joints. They cost you less per foot of hole drilled. *Replacement is not necessary* — "Flash-Weld" tool joints last the life of the drill stem! The heavy wall section and the absence of pipe threads permit "Flash-Weld" joints to be safely rehardfaced in the field.

With HUGHES "Flash-Weld" you get the industry's greatest flash-welding experience. More than 35 million feet of drill pipe have been unitized with this superior tool joint!

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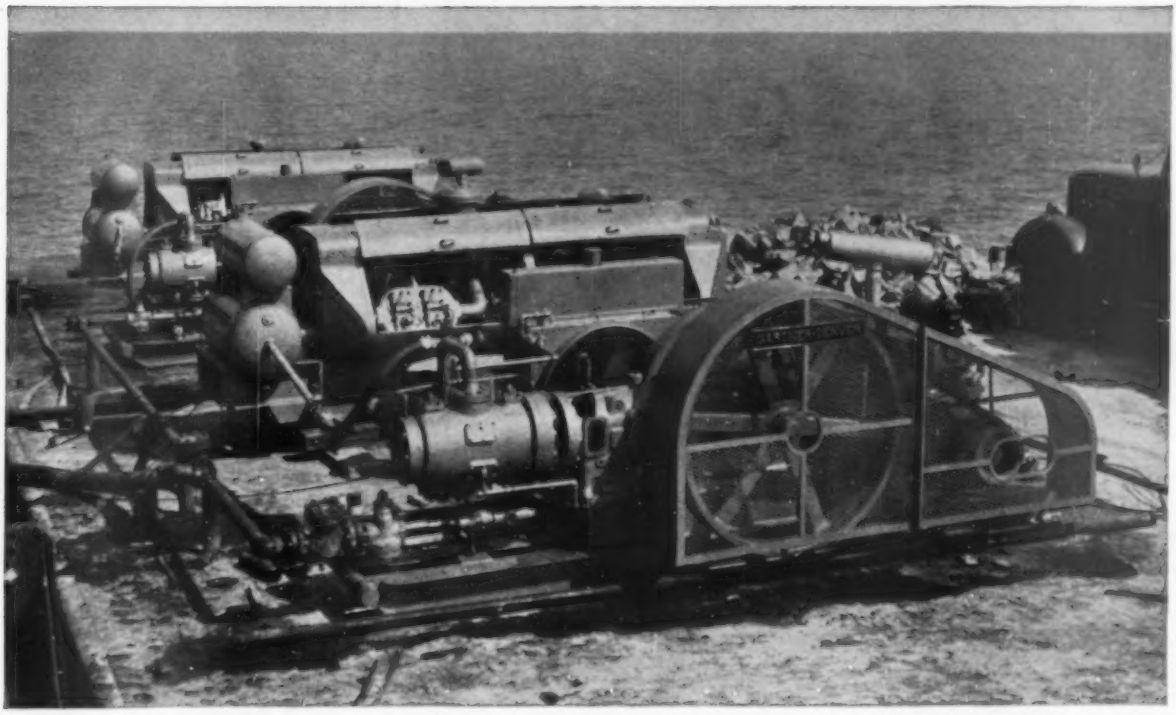
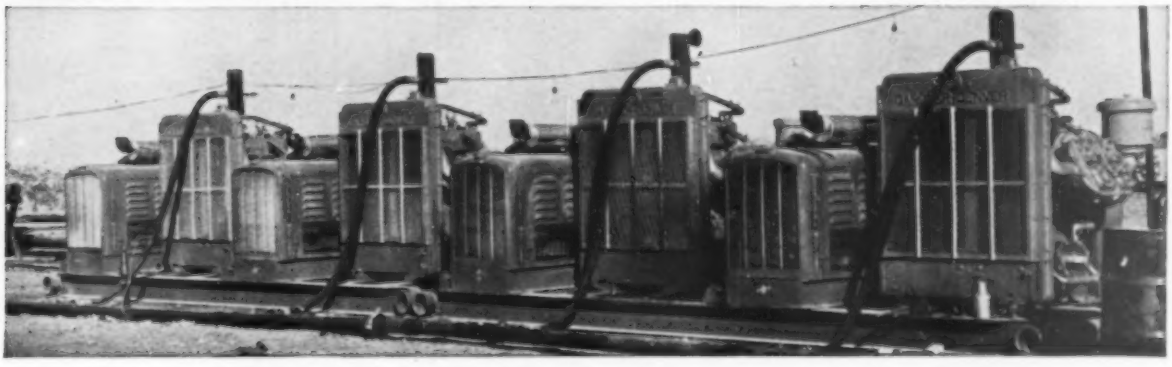
Bit for bit, regular or jet, you will find that *consistently*—day-after-day—you get faster penetration and more hole per bit with Hughes bits. The superior performance of Hughes bits has been proved in hundreds of thousands of wells—not just a hand-picked few—and in the drilling of more than a billion feet of hole throughout the world. HUGHES bits enable you to get your well down in the shortest possible time... and to take *full* advantage of new drilling techniques.

Gardner-Denver . . . Serving the World's Basic Industries





Afloat . . . or ashore . . .
it's Gardner-Denver for air drilling

Rotary or piston-type portables—600 cfm—water-cooled for steady running in any weather.

WB skid-mounted units—to 1150 cfm—compact, efficient, with self-contained cooling system.

RX skid-mounted horizontal compressors—to 1292 cfm—for continuous service 'round the clock.

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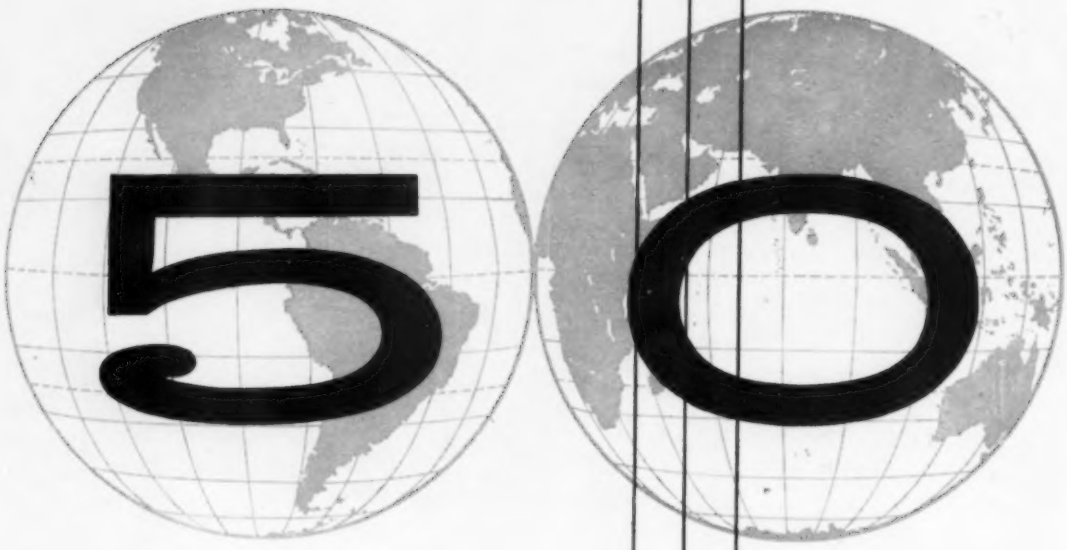

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D+B Precision Sub-surface Pumps by EMSCO

For more efficient and economical production under any type of pumping problem – in deep wells or shallow – under sandy, corrosive, gassy, crooked or slant hole conditions – you'll find a D+B Precision Sub-surface Pump to meet your need. The best materials, excellent workmanship, and rigid inspection, backed by 50 years of research and know-how, combine to make D+B Pumps the choice of experienced operators everywhere. For bulletins and details on D+B Pumps and Parts, call your nearest CONTINENTAL or D+B store. Make use of our pump shop service.

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P-601

HOW TO get mud valve economy

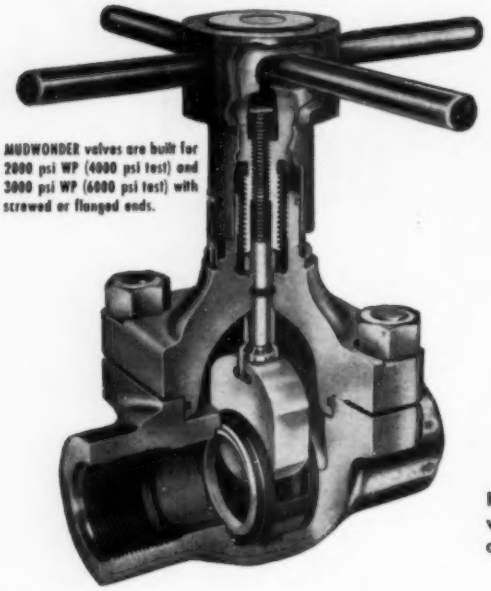
Switch to competitively-priced
Rockwell-Built **MUDWONDER**
Valves for ALL mudline services

Longer wearing parts which can be replaced easily and quickly are causing the big switch to MUDWONDER by cost-conscious drillers.

Whenever maintenance is needed, the operation is simple. Bonnet assembly lifts off without disturbing the mudline hook-up.

Inspection or part replacement, if necessary, can be made while the crew is making a connection. Extra seats and, perhaps, a gate for each size—both are interchangeable between pressure classes—are all the parts inventory you should need.

Replace troublesome mud valves today with MUDWONDER. Drilling men everywhere are switching to MUDWONDER. They've tried it—even abused it—to prove its economical superiority for installation, for operation, for maintenance.



MUDWONDER valves are built for 2000 psi WP (4000 psi test) and 3000 psi WP (6000 psi test) with screwed or flanged ends.

Here is the wear-absorbing heart of the MUDWONDER— Hard-chromed gate in combination with buna-N seat molded integrally over steel wear rings resist abrasion.

On your rig you can expect the Rockwell-Built MUDWONDER to: SLASH DOWNTIME . . . ASSEMBLE EASILY . . . GIVE LONGER SERVICE . . . OPERATE EASIER, FASTER . . KEEP MUDLINES INTACT . . . STOP SANDING UP

Ask your favorite oil field supplier for more information or write to Edward for Catalog 12-S.

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Major decisions are easier to make when you have complete confidence in the accuracy and source of your data. In evaluating a formation, and the producing potential of a reservoir, you'll get the highest degree of accuracy and the most advanced technical data from a Halliburton Drill Stem Test.

Halliburton leads the class in all these major points:

HYDRO-SPRING TESTER is the most mechanically perfect testing tool	**BY-PASS & PRESSURE EQUALIZER** provide faster, safer, easier runs—saving much downtime	**EXPANDING SHOE PACKER** gives most efficient performance and comes out of hole intact
SIDE WALL ANCHOR ASSEMBLY permits more accurate Off-Bottom Testing anywhere up the hole	**BOURDON TUBE GAUGE** is the most precise pressure recording device for Dual CIP	**HYDRAULIC ADJUSTABLE CHOKE** controls initial flow of fluid and reduces shock when tester opens

This all-in-one testing service answers almost any question you could ask about your well. Makes your all-important decision easier for you and gives utmost confidence in correctness. There is no higher degree in advanced testing than Halliburton's DST. Why not use it next time? Just phone your local or district office of the Halliburton Oil Well Cementing Company.

COMPLETE DATA SENT ON REQUEST *Add this valuable information to your Halliburton Service File*

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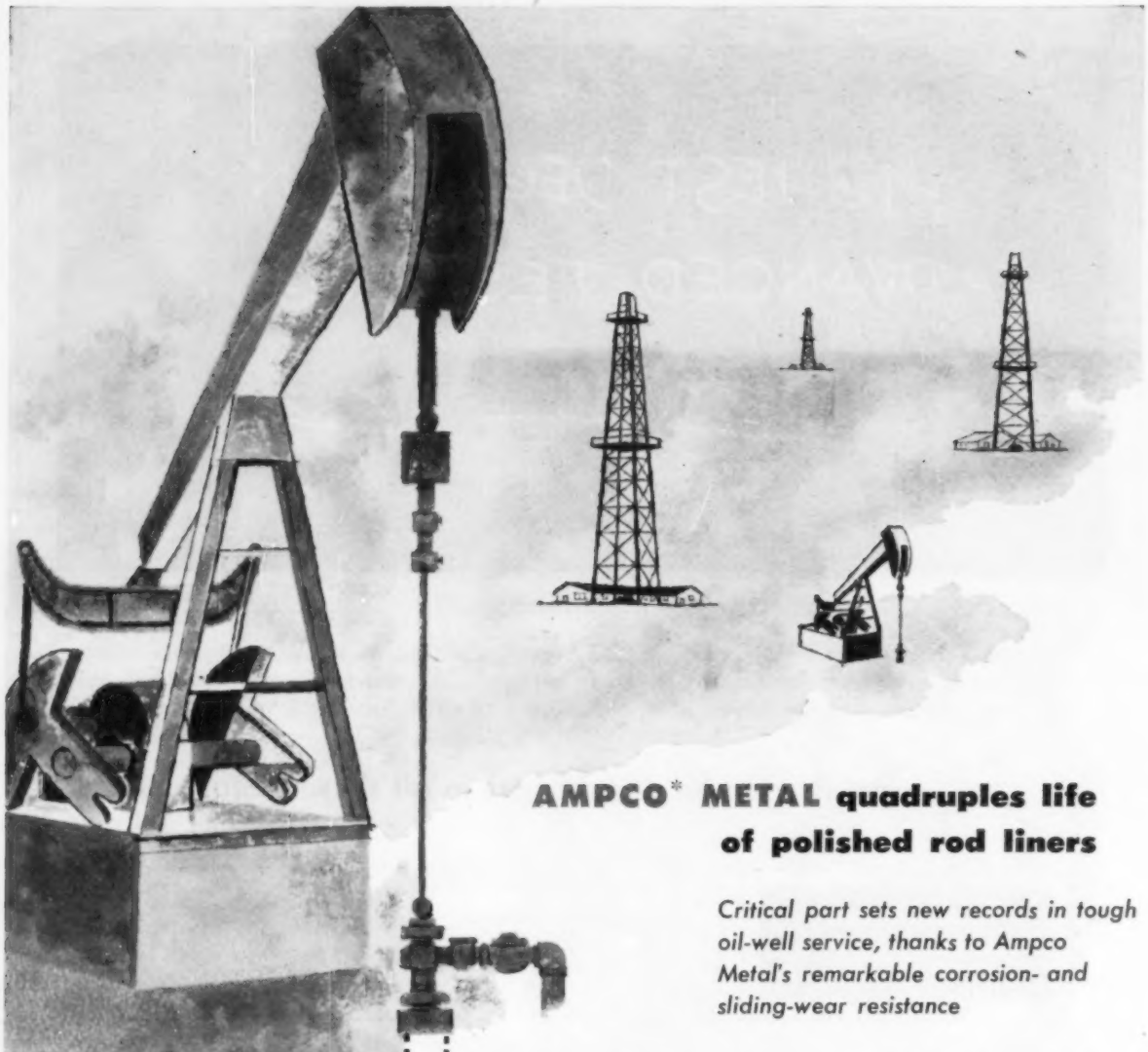
TESTING SERVICE

250 SERVICE CENTERS—JUST MINUTES AWAY FROM ANY RIG



AMPCO* METAL quadruples life of polished rod liners

Critical part sets new records in tough oil-well service, thanks to Ampco Metal's remarkable corrosion- and sliding-wear resistance

In oil well pumping the 14 to 16-foot polished rod liner really takes a beating. As you can imagine, sliding wear, in this extra-long bushing, is a real problem when you consider the number of strokes made by a pump during an operating day. Corrosion enters the picture, too, with the liner often in contact with salt water, sulfides, etc.

With ordinary bronzes, Cities Service Oil Company found frequent replacement to be a constant headache. Then, in certain areas, it switched to liners made from Ampco Metal Pipe. Cities Service engineers report a substantial reduction in liner replacements.

Ampco Metal Liners last four times as long as plain bronze liners because they are made from a unique aluminum bronze alloy. It's a remarkable bearing material—has unusual resistance to mechanical wear. It withstands the corrosive effects of many acids and caustics. And when used as pipe it combats erosion from solids held in suspension.

Ampco pipe and tubing is available in all sizes, along with a complete line of flanges and fittings. Send coupon today for full information.

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AMPCO METAL, INC.
Dept. PE-3, Milwaukee 46, Wisconin

I'm interested in knowing more about Ampco Polished Rod Liners. Please send me complete information.

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Company.....

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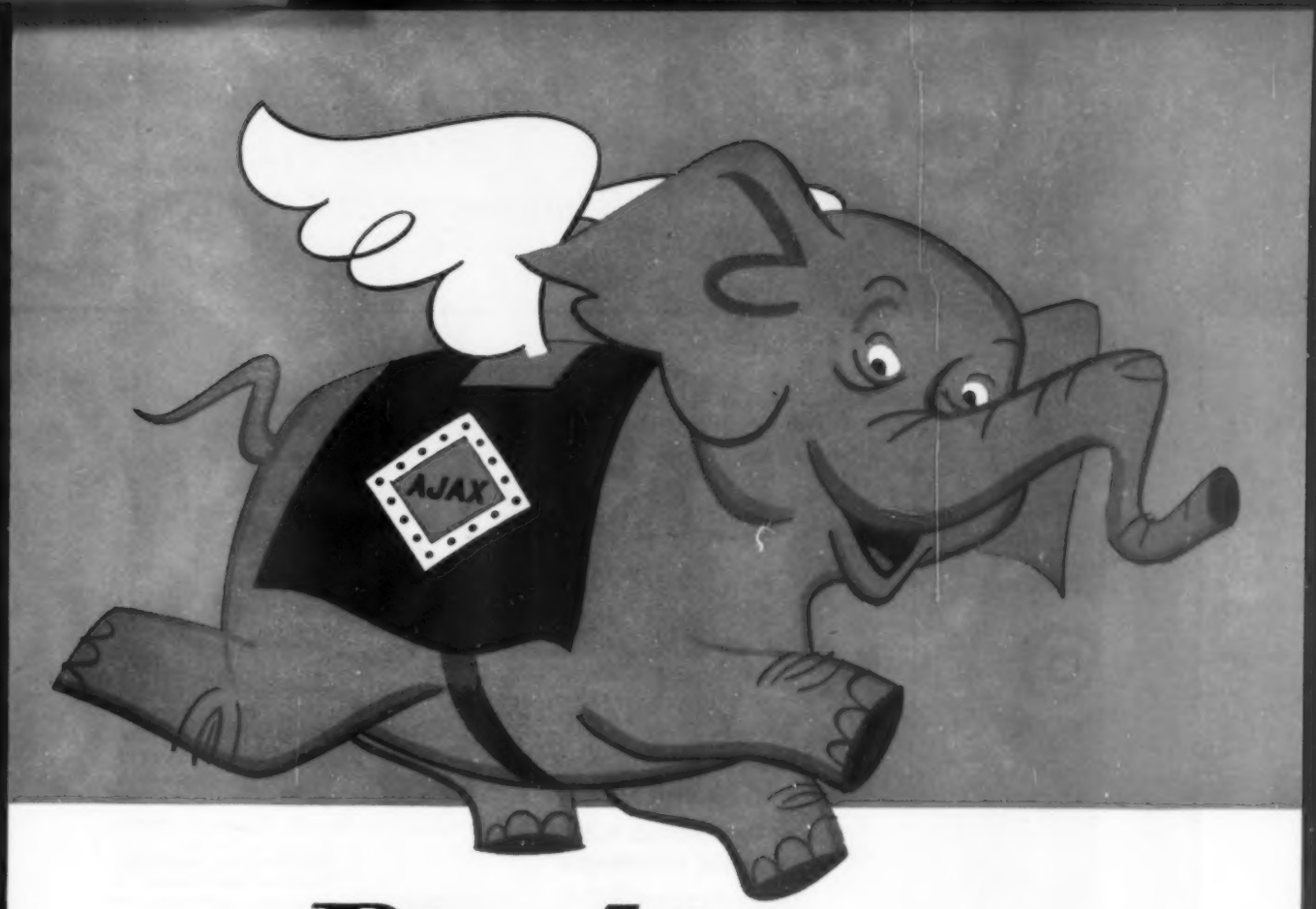
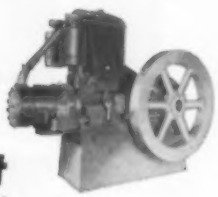


THE *Big Ajax* IS ON THE WAY



for the tough jobs that
only the strongest
can handle so well!

AJAX DP*-115 13¼ x 16 GAS ENGINE

The mighty new AJAX DP*-115 is the oilfield engine with the "mostest"—in muscle, stamina, low maintenance, long life. With three years of development and field proving already behind it, the 13¼" bore, 16" stroke DP-115 does a workhorse job 24 hours a day. It maintains an essentially flat torque curve, delivering the required horsepower to operate pumps or other equipment over a wide speed range . . . variable to suit operating conditions. Write for performance details now—call your Supply Man for the Big Ajax facts that apply to your most difficult pumping problems!

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Builders of GAS AND OIL ENGINES, PRESSURE PUMPS,
STEAM DRILLING ENGINES, INDUSTRIAL STEAM ENGINES

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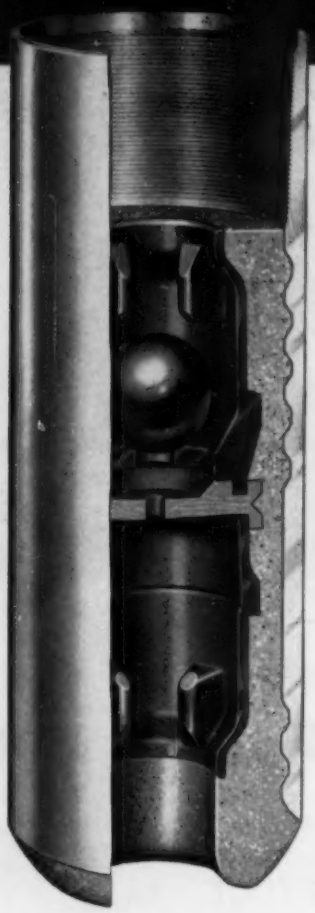
*DIRECTIONAL PORTED
115 usable horsepower!

AUTOMATIC, REGULATED *FILL OF THE CASING* AS IT IS BEING RUN

***PROTECTION AGAINST DESTRUCTIVE HIGH-PRESSURE SURGES**



with

BAKER FLEXIFLOW

FILL-UP SHOES AND COLLARS

Baker Flexiflow Fill-Up Equipment, a new companion line to Baker Differential Fill-Up Equipment is designed to be run in wells of moderate depth.

FEATURES

SELF-ADJUSTING FLOW CONTROL DIAPHRAGM

Baker Flexiflow Fill-Up Equipment contains a variable valve (Self-Adjusting Flow Control Diaphragm) that automatically opens wider or closes down to provide MINIMUM BOTTOM-HOLE PRESSURE INCREASES and regulated fill of the casing.

POSITIVE BALL-TYPE BACK-PRESSURE VALVE FOR CEMENTING

A Ball-Type, Back-Pressure Valve for floating or cementing can be brought into action at any time by applying a pressure of approximately 700 psi to the casing. See Figs. 2 and 3 below.

COMPLETELY DRILLABLE

The internal parts of Flexiflow Fill-Up Shoes and Collars consist of readily drillable concrete, a small amount of Bakelite and synthetic rubber.

ECONOMICAL

Baker Flexiflow Fill-Up Equipment not only permits the casing to be run more rapidly with greatly reduced pressure increases or surges on the formations below the shoe, but in addition, by eliminating the surface-filling operation, saves an additional amount of rig time. When these advantages are considered, Flexiflow Equipment is much more economical to run than conventional floating equipment.

***Pressure surges over 5,000 psi can be created each time a joint of casing equipped with conventional floating equipment is lowered under certain slim hole clearances.**

High-Pressure surges can fracture and weaken a formation sufficiently to cause lost circulation or the failure of a primary cement job.

These destructive, high-pressure surges can be reduced . . .

- **by increasing the lowering time per joint**
- **by increasing the casing clearance**

or

- **by running Baker Flexiflow (or Differential) Fill-Up Shoes and Collars**

NOTE:

Baker Fill-Up Equipment contains a variable valve that automatically opens up and adjusts to maintain minimum bottom-hole pressure as the casing is being run.

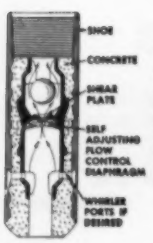


FIG. 1 Casing Filling while going in the hole

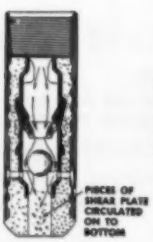


FIG. 2 Ball pumped through diaphragm

FIG. 3 Ball shut-off against cement back-pressure

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OIL TOOLS, INC.
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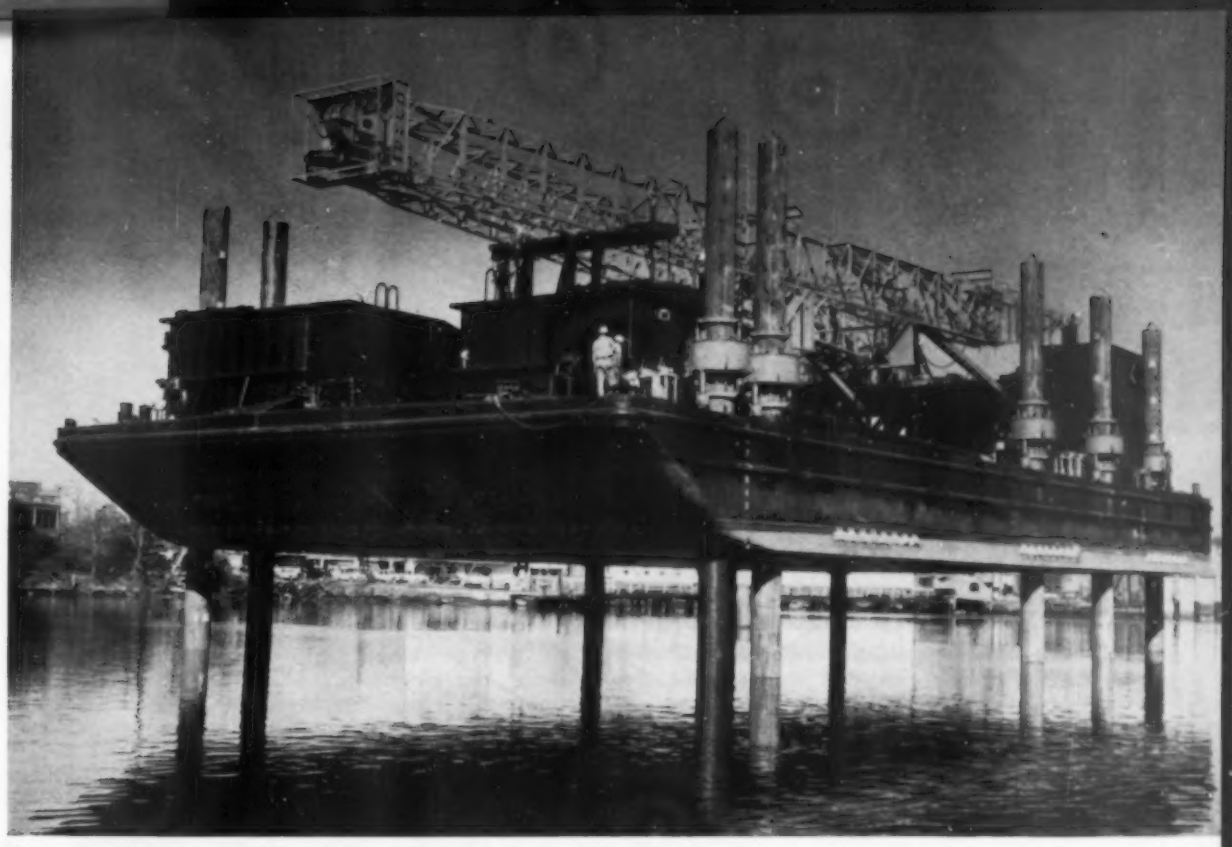


Mene Grande's Barge 72 under test. Barge jacked up to operating position while mast remains at rest in cradle. Barge is moved, raised and lowered while mast is in this position.

P 422.912.

Latest Ideas Go Into . . .

New Spud-Type Mobile Drilling Barge

Slated for Lake Maracaibo duty by Mene Grande, Barge No. 72 features:

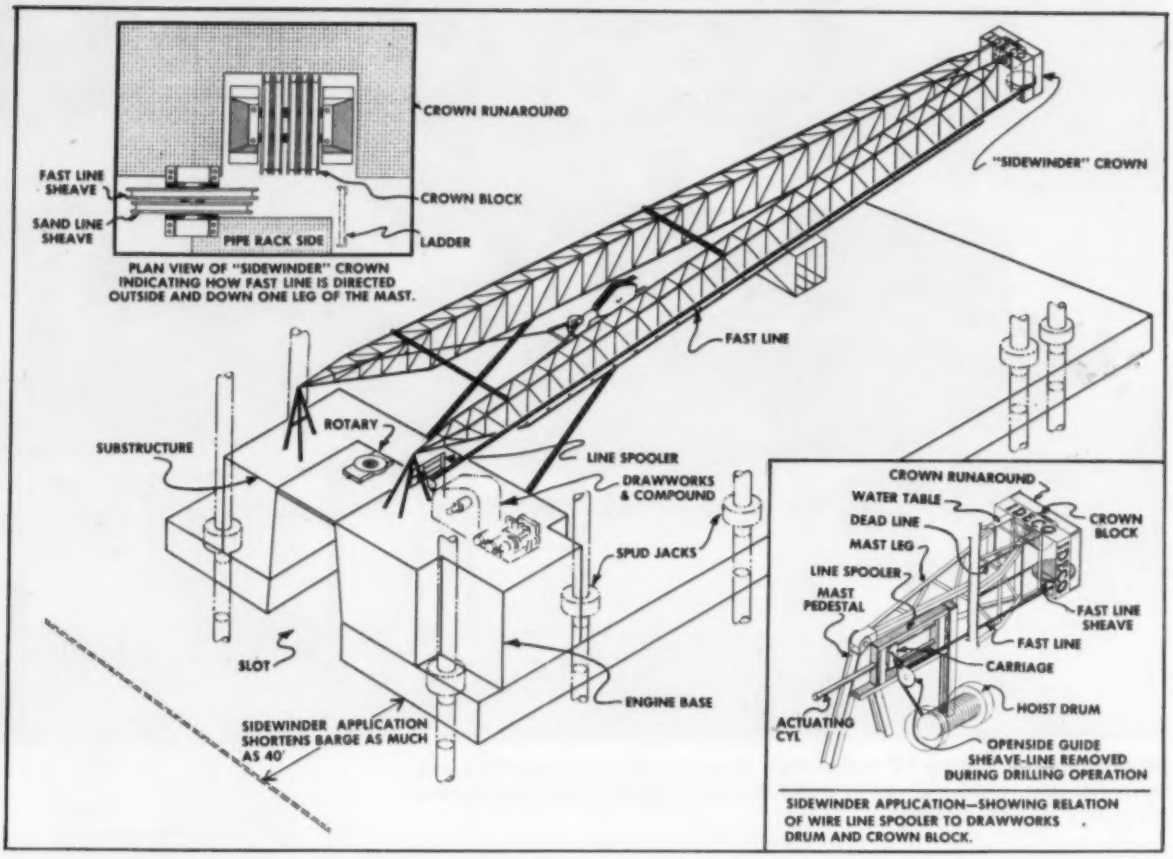
- ***New idea in location of drawworks.***
- ***Shorter slot to accommodate well head.***
- ***Concentration of equipment in small area.***
- ***New type hydraulic spud jacks.***

THE latest in design features and equipment have gone into a new spud-type mobile drilling barge built for Mene Grande Oil Company of Venezuela. Its ultimate destination is Lake Maracaibo, but Barge No. 72 will make a test run in the States before its ocean voyage across the Gulf of Mexico. It will be employed under charter by Gulf Refining Company to drill a well about 5 mi east of Venice in coastal Louisiana.

Designed by Friede and Goldman, Inc., of New Orleans, Louisiana, and constructed by Levingston Shipbuilding Company of Orange, Texas, this new mobile drilling barge was especially made and equipped for drilling in waters up to 25 ft deep and for conditions found in Lake Maracaibo.

Barge No. 72 measures 143 ft long, 65 ft wide and is 10 ft deep. Basically, it is similar to one operated by Gulf Refining Company in Caddo Lake for several years. It differs, however, in the size of the slot at one end to accommodate the wellhead equipment when the barge is in a floating position. The slot is 12 ft wide and only 17 ft in length. It is not centered as is conventional practice, but is offset from center.

The barge is raised and lowered some 10 ft above water level by means of hydraulic jacks. These jacks lift the barge on ten 30-in. OD outside spuds measuring 60 ft in length. They have a wall thickness of $\frac{5}{8}$ in. There are

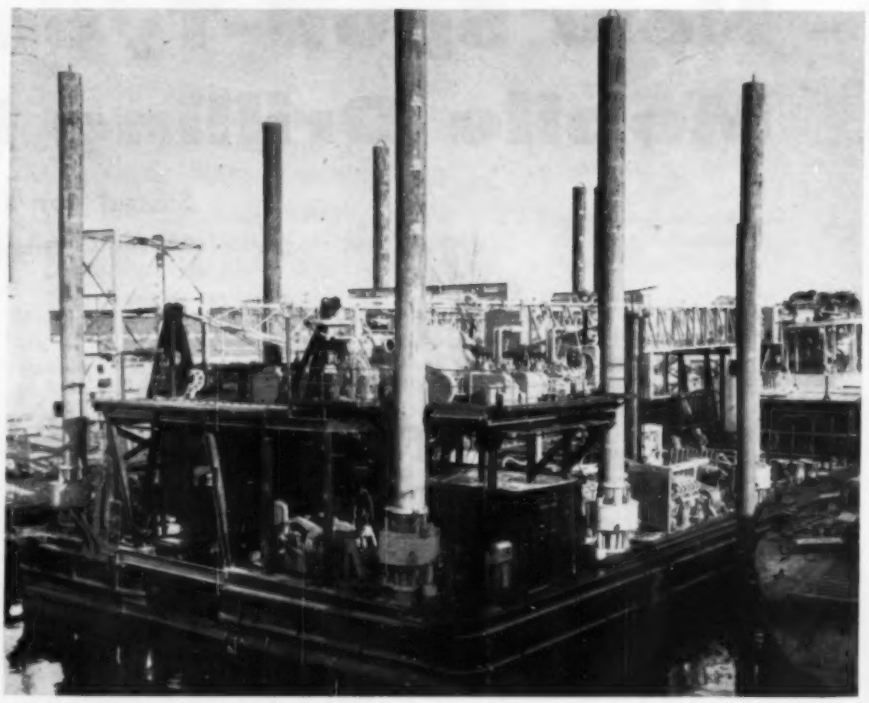


Ideco's sidewinder feature incorporated in Mene Grande's Barge 72. Inset is diagram of new crown block design to feed fast line outside of mast leg. Note position of drawworks in relation to mast.

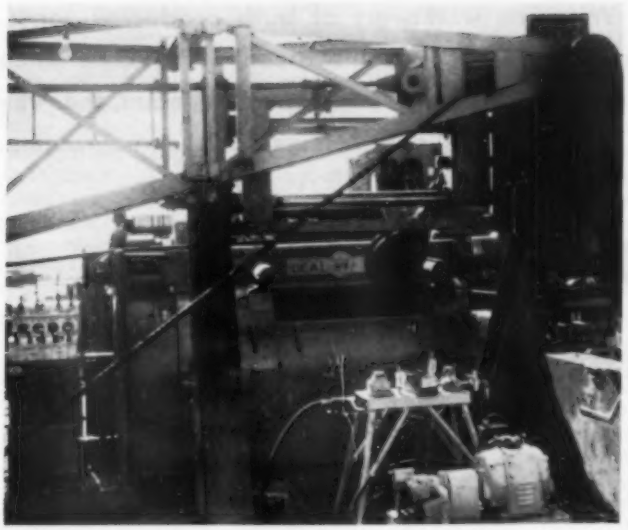
five spuds on either side of the barge. Two are located at the forward end and three are located towards the "working" end of the barge which carries the heaviest concentration of weight.

New-Type Hydraulic Spud Jacks. A new custom-designed, hydraulic spud jack made by Joe Stine, Inc., of Houston, Texas, provides the power to lift the weight of the barge and all drilling equipment to a height of 10 ft above water level. These jacks are also used to lower the barge. Each jack comprises two hydraulic pistons that manipulate a doughnut-shaped ring which houses the engaging mechanism that grips the 30-in. OD spuds. When the slips of the engaging mechanism are set, the jack has a 4-ft piston stroke. Hydraulic hoses connected to these jacks supply the pressure necessary to make the lift. All jacks are operated in unison to provide even lifting and lowering without tilting the barge.

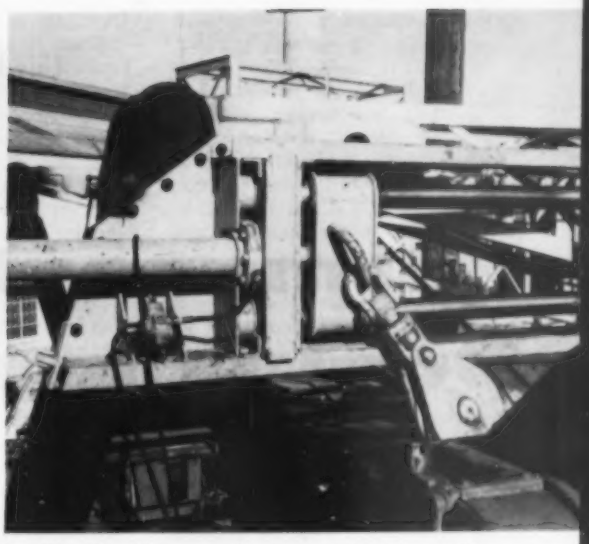
Drawworks at Side of Mast. Newest feature in mobile drilling barge design was incorporated in Mene Grande's Barge No. 72. Instead of



Drilling equipment concentrated in small area on aft end of barge. Note location of drawworks and compound in relation to mast legs.



Drawworks and compound face side of mast in "Sidewinder" application. Hydraulic control for spooling device is portable and may be located in front of the drawworks during raising and lowering the mast.



Hydraulic wire line spooler mounted in front of drawworks. Large diameter heavy-duty block in foreground feeds wire line from drawworks drum to fast line sheave of the crown block during the mast raising and lowering operation.

placing the drawworks in the conventional position over the slot and in back of the mast, the drawworks are mounted outside of and facing the mast legs on the driller's side of the mast.

While the advantage of this idea may be somewhat obvious to the marine driller, it is probably less obvious to the dry land driller. The size of a barge is a big influencing factor in overall barge cost. If conventional practice had been followed, the drawworks, engines and engine compound would have been located "behind" the mast. To do this would have added length to the barge and would have required a much longer slot to accommodate the wellhead equipment when the barge was floating.

The barge's present 165-ft length makes it possible to lower the 133-ft mast and nestle it in a cradle during moves from one location to another as well as when raising or lowering the barge. By locating the drawworks and driving engines with compound to one side of the mast, the overall barge length was reduced by some 30 ft. This accounts for the relatively short slot in the barge and also accounts for not centering the slot at one end of the barge.

Ideco, one of the Dresser Industries, solved this problem by redesigning the crown block and designing a unique wire line hydraulic spooling device. The idea is referred to as the "sidewinder" feature since the drilling line is spooled to the side of the mast.

Drawworks Location Poses Problem. Biggest problem to overcome by this "sidewinder" idea was that of spooling the wire line when raising and lowering the mast. Also, the crown block had to be modified to feed the fast line on the outside and down one leg of the mast. The crown block is actually two blocks in one, with the fast line sheave at right angles to the crown block cluster. The drawworks drum is exactly centered on the fast line sheave for optimum spooling.

Hydraulic Line Spooler. Mounted immediately in front of the drawworks drum and to a pedestal of one mast leg is a hydraulically actuated wire line spooling device especially designed by Ideco for this type drawworks arrangement. Purpose of the hydraulic line spooler is to spool the drilling line evenly onto the drawworks drum when the mast is being raised or lowered. Once the mast has been raised, the wire line is disengaged from the block on the hydraulic line spooler allowing the line to feed directly from the drum to the fast line sheave in the crown block.

The line spooler device consists of a double-acting hydraulic ram mounted on a rectangular steel frame. This frame is bolted to one of the mast leg pedestals. The ram, or piston, pushes and pulls a carrier or head across two parallel guide bars. To this head is attached a heavy-duty large-diameter block through which the wire line feeds from the drum to the fast line sheave of the crown block.

Hydraulic controls for the spooler are mounted on a portable bench, and when the spooler is in operation, these controls are located in front of the drawworks just inside one mast leg to allow the operator full view of the drum. By means of a simple directional control valve, the operator can control the travel of the spooler ram, and thereby evenly spool the wire line on the drum during raising and lowering of the mast.

The hydraulic cylinder is powered by a standard Denison pump unit located conveniently below the rig floor. The spooler controls can be moved out of the way during normal drilling operations or adjusted to give the operator maximum visibility of the drum during spooling. While one operator controls the action of this spooler device, the driller controls the drawworks during raising and lowering the mast. Use of this hydraulic wire line spooler does not effect the time required to raise or lower the mast. The idea can be used on any mast of this type if the crown block is equipped with a fast line sheave to direct the drilling line outside the mast and down one leg as illustrated.

Other Rig Components. The drawworks is a National type 55 intended for drilling in the 5000-7500-ft depth range. It is rated at 550-hp and is powered by General Motors "twins" rated at 420 bhp at 2100 rpm.

The mast, drawworks, engines and power compound are located on an elevated deck, providing additional space below on the main barge deck. The two main mud pumps are separately driven and are located on the main barge deck immediately forward of the derrick floor structure. Mud storage, tool house, crew compartments, etc. are housed on the forward end of the barge. ★ ★ ★

Wire line workovers of both producing zones. This has been done in some recent wells. Experience and new developments point the way for such completions to become routine.

Permanent-Type Dual Completions

G. H. Tausch,
John W. Kenneday
Humble Oil & Refining Company, Houston, Texas

ALTHOUGH considered of questionable soundness only a few years ago, dual completions are now field-proved and generally accepted. An improved, single-tubing dual, permitting through-the-tubing wire-line servicing and recompleting of the lower zone, was designed to help solve many of the problems associated with such completions. This versatile permanent-type dual completion has reduced initial completion problems, provided flow versatility, and reduced workover costs. Routine servicing operations in this installation have included cementing, reperforating, sand removal, artificial-lift repair, well stimulation, and sand exclusion. Because of the success of this dual, the concept of a permanent-type dual completion was adapted for use with parallel tubing. This application offers the advantages of tubed flow. An additional advantage is that workover of the lower zone may be performed without interrupting production from the upper zone.

Recently, some dual completions have been installed that permit wire-line workovers of both upper and lower zone. This technique is being expanded for use through 1½-in. tubing with parallel tubing strings in 5½-in. casing. With these developments and a background of successful field experience, permanent type dual completions permitting wire-line workovers of both zones may become routine.

Increased cost of drilling wells, limited allowables, relatively low additional cost of the second completion, and improved completion equipment offered by equipment manufacturers have made dual completion of oil and gas wells extremely attractive in recent years. With dual completions, however, have come the inherent problems of increased workover costs, sand exclusion, and artificial lift. In an effort to utilize the permanent-completion technique,[1,2] to reduce workover costs of dually completed wells, a dual-completion installation was designed to permit all zones below the lower packer to be reworked without pipehandling equipment. The original installations utilized flow through the annulus.

With every type of dual completion an effort has been made to leave as many zones cased off below the lower packer as is practical to permit more wire-line workovers. When present, a zone having an anticipated long producing life is selected for the upper-zone completion. Inasmuch as only the lower zone may be reworked without a rig, generally this is the only zone perforated[3,4] in salt water or clean fluid. Usually the upper zone has been perforated in drilling mud during initial completion because the tubing is not in place. Thus mud plugging of the perforations is still present in the upper zone.

Requirements for permanently completed duals are the same as for single completions. The tubing must be relatively full-opening to permit passage of the tubing-type perforator and retrievable tubing extension, must be pressure-tight to the point of suspension of the tubing extension, and must have a circulation port between tubing and annulus or between two tubing strings. All requirements except the full-opening one are usually present with other dual installations. An effort has been made to design all equipment for permanent dual completions with minimum outside diameters to permit easier fishing operations — a feature often overlooked with conventional duals.

Because the lower packer need never be removed, a drillable packer is generally selected. Setting this drillable packer by collar log measurement further assures the depth correlation so essential with dual completions. As with most permanent completions, the flapper valve is usually omitted from the drillable packer to facilitate removal of tubing extension and well tubing as a unit should such action become necessary. Because the upper zone is reworked with a rig, the upper packer is usually of the retrievable type. Should it become possible to remove a drillable packer without actually drilling the packer body, as by washing over the packer with special hardfaced washover shoes, a drillable packer may become equally popular. The retrievable packers have been compression-set, mechanically set, or differential-pressure cup types. When a mechanically set packer is used which requires rotation, a pressure-tight swivel is placed between the upper and lower packers to eliminate rotation of the production tube in the lower packer.

One of the problems inherent in all dual completions is artificial lift. With permanently completed duals it is desirable that artificial-lift equipment be retrievable without pipe-handling equipment. The economy of retrievable artificial-lift equipment is readily recognized because of the high cost of removing and replacing one or more tubing strings, the loss of production from two wells during the operation, and the high cost resulting from occasional trouble and routine repair of packers that must be retrieved and rerun. Gas lift with dual completions has emphasized the need for efficient fluid-operated or tubing-pressure-controlled

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valves to permit simultaneous artificial lift of two zones with a common gas source.

Inasmuch as the upper zone is initially perforated in mud and production is usually limited to a few unplugged perforations, the problem of fluid or sand cutting of the tubing opposite these upper perforations is present. Various tubing coverings such as lead and rubber as well as metallic coatings and additional wall thickness have been used to protect the tubing. None of these devices has been outstanding in its success in all areas. It has long been surmised that perforating in clean fluids and the use of a satisfactory sand-exclusion process, when necessary, would eliminate the need for tubing protection opposite the upper zone.

The wire-line workover costs for permanently completed duals are approximately the same as the costs for single completions, occasionally slightly greater. The cost saving with duals, therefore, is greater as conventional workover of dual wells is inherently more costly. Some types of parallel-tubing duals even allow the upper zone to be produced while the lower zone is being reworked, thereby avoiding loss of production from one zone.

Recently, the trend with dual completions has been to independent parallel tubing strings in which the flow from both zones is isolated to the tubing. This type installation has the advantage of preventing high-pressure, corrosive, or sandladen well fluids from contacting the casing. Often better flow characteristics are obtained through tubing flow than through annulus flow.

Successful cost reduction effected with wire-line workovers of zones below the lower packer created demand for a dual completion installation permitting rework operations on the upper zone without pipe-handling equipment. A number of wells have been completed with retrievable tubing opposite the upper zone. This tubing may be removed with a wire-line to permit all manner of cleanouts, perforating, and remedial operations to be performed on the upper zone.

The obvious attractiveness of parallel-tubing installations, coupled with the desire to dually complete old wells having 5½-in. casing, has created the need for development of a special type of dual. To satisfy this need, one well has been completed to test the practicality of running two strings of 1½-in. tubing indpendently, reworking both zones without a rig, and artificially lifting both zones simultaneously.

Tubing-Casing Annulus Flow

The initial permanent-type dual completion was installed several years ago. Industry-wide, there are now approximately 300 installations of this original type. The subsurface equipment consists of two packers with communication ports immediately above and below the top packer and a landing nipple above the top ports. A retrievable choke permits both straight and crossover flow as shown in Fig. 1-A and 1-B. Because the length of the upper packer determines the minimum length of the choke, short packers such as the cup-type packer with slips molded in the cup seals have been attractive.

Shortly after the initial installations, this type dual equipment was redesigned so that side-port and landing nipples were tubing-collar diameter or smaller, thus permitting the use of drillable upper packers if desired. The ability to change producing intervals without a rig necessitates the two-packer installation in order to permit crossover flow. This upper packer also is used to isolate the upper zone during wire-line remedial work.

Another type of tubing and annulus flow installation illustrated in Fig. 1-C consists of a single packer separating both completion intervals and a small parallel tubing string which joins the production tubing above the packer. This small tubing is used for artificial-lift and workover purposes.

Installations of duals having an annulus flow path are often unfavorable in wells having severe paraffin, corrosion, sand, and high-pressure production problems.

Workovers. Approximately a dozen workovers have been performed in wells having a two-packer, single-tubing installation. After retrieving the flow choke, the wells were killed by circulating with salt water through the side-port nipple above the upper packer. The upper zone was isolated while using the tubing extension by a concentric bypass which seals in the lower side-port nipple with chevron packing. This concentric bypass permits flow through the extension and be-

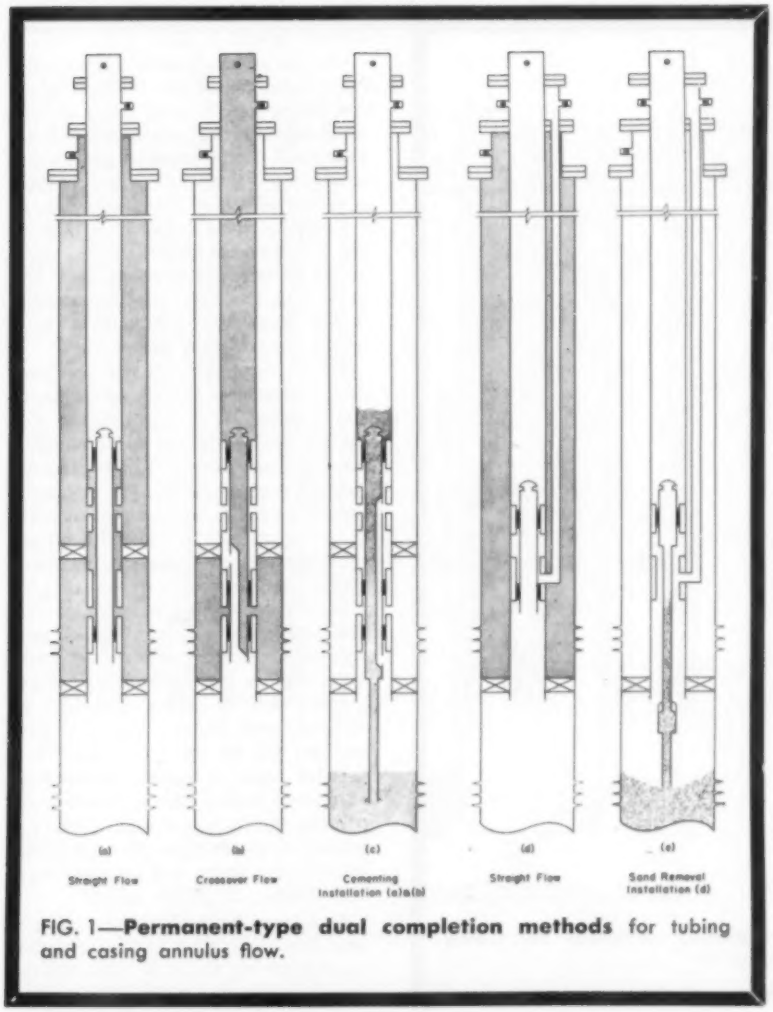

FIG. 1—**Permanent-type dual completion methods** for tubing and casing annulus flow.

tween the extension and outer sleeve containing chevron packing. The well setup using the tubing extension is shown in Fig. 1-D.

Initially this assembly was tested by using a slidably mounted packing sleeve on the extension opposite the lower extremity of the production tubing. Pressure applied to the casing tested the concentric bypass, tubing, and upper packer; additional pressure sheared a pin holding the lower packing sleeve and forced it from the end of the production tubing, thereby opening the necessary flow path. This tool proved clumsy, and a test packoff ring was later incorporated into the concentric bypass. With this new concentric bypass it is possible to pressure test the entire assembly and ascertain that the extension is locked in place before performing any remedial operation.

Workovers have consisted of dissolving aluminum gun cases with caustic soda, sand removal, cementing,[2, 5] perforating, and all operations performed on conventional wire-line workovers. Cementing operations have consisted of both recementing and change of interval. In one well it was necessary to squeeze-cement existing perforations, dry test, and perforate deeper zones. No difficulties have been experienced because of the fact that the wells were dually completd.

On one occasion when an exceptionally long extension — 1100 ft in length — was being used, the bypass mandrel and extension hanger were joined with a short length of aluminum pipe. After successfully cementing, the aluminum pipe parted above the bypass when an attempt was made to retrieve the extension. The cement job was successful, and the extension was found to be stuck by fracturing sand from a previous operation. It was not ascertained whether the small length of aluminum pipe was faulty, but it is considered wise to join bypass and extension hanger with iron pipe to assure their removal as a unit.

The dual installation using one packer and a parallel small tubing string is reworked in the same manner as a single completion. The retrievable tubing extension is seated in a nipple located above the junction of the parallel strings and the small string is used in place of the annulus flow path. In fact, when a circulation port that is full opening when closed such as a gas-lift mandrel is used, the upper zone may continue to flow during the workover thus assuring less loss of oil production. The use of the extension for sand washing is illustrated in Fig. 1-E.

Artificial Lift. As more wells were completed as duals the problems of artificial lift became apparent. This problem has been solved in many ways depending upon the type of artificial lift desired and well conditions. Fig 2-A shows one manner of gas lifting both tubing and annulus by using short strings of small tubing independently suspended down the production tubing and externally clamped to the production tubing. Conventional gas-lift valves on both strings of small tubing supply the necessary gas-injection points. When the gas-injection point is shallow, the small tubing is run open-ended with no valves.

On occasions, retrievable gas-lift valve mandrels are run in the production tubing with a small string of tubing clamped to the production tubing. This small tubing supplies gas for the retrievable valves and also contains conventional valves for injecting gas in the annulus. This installation, such as Fig. 2-B, does not require that the small tubing be removed to permit wire-line workovers. Once the gas-lift mandrels in the production tubing have been closed, the well may be reworked.

Other installations made complete use of retrievable gas-lift valves. Small tubing string are clamped to the production tubing and are made continuous by constructing small conduits through each mandrel. The mandrels are run in pairs, one for gas injection to tubing and one for injection to annulus. Some installations use the annulus for gas-lift gas and one small 1-in. string for conducting well production. The installation shown in Fig. 2-C permits the use of the two small 1-in. tubing strings as independent gas-lift gas sources. Gas-lift valves need only be replaced with dummy valves to prepare the well for wire-line workover.

Other types of gas-lift installations have been made. Many varieties are possible, but the use of small tubing for gas-lift or production prevents large-volume production and usually lowers lift efficiency at greater depths.

Free-type hydraulic pumps have been popular in some areas as a means of artificial lift. Fig. 2-D illustrates the use of a rod pump in the single-packer,

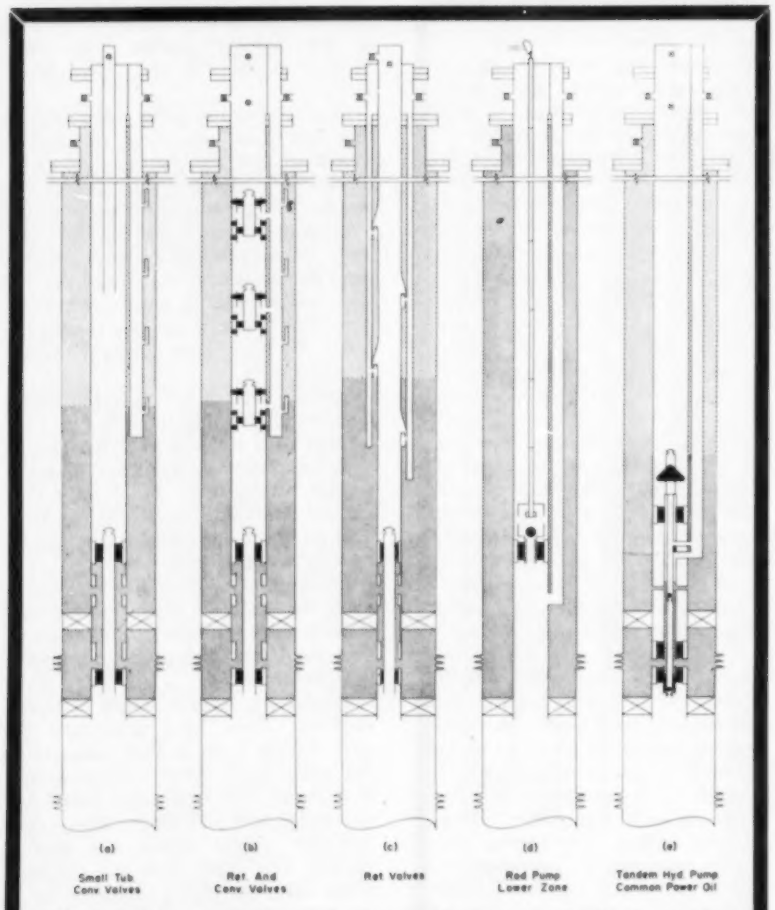

FIG. 2—**Permanent-type dual completion methods** for tubing and casing annulus flow utilizing artificial lift.

parallel small-tubing installation previously described. A hydraulic pump is frequently used in this same installation. The small tubing is used for lower-zone production when flowing or pumping with free-type hydraulic pumps and the annulus for flowing upper-zone production. A variation of this completion, shown in Fig. 2-E, consists of two packers and tandem free pumps. The hydraulic pumps have a common power-oil supply, and this power oil is commingled with production from one zone. With both of these installations, the free pump is circulated from the well, and the standing valve is retrieved with a wire-line before workover operations commence.

Parallel-Tubing Flow

The safety and versatility of parallel-tubing installations have made these completions popular in recent years. Whenever possible, completions are designed to permit running and retrieving each tubing string independently. When run independently, the tubing used for conducting lower-zone production generally is used to run and retrieve the upper packer, thereby allowing this packer to be set with the first tubing string. The upper-zone tubing is seated in the upper packer and sealed with packing, and may be retrieved without unseating the packer. This type completion is illustrated in Fig. 3-A. There are now approximately 200 of these parallel-tubing installations within the industry. Tapered collars or integral joints are used on the production tubing to facilitate running and retrieving.

A landing nipple is placed above the upper packer in each tubing string for suspension of the tubing extension. A sliding sleeve-type circulating valve is run in each string between the landing nipple and upper packer to permit communication between either tubing and the casing annulus. Cup-type packers are widely used because they permit a larger passage through the packer to the upper zone. However, the upper-zone tubing is generally not full-opening through the upper packer. For complete versatility, this packer should permit passage of a wire-line tubing extension so that sand may be washed from around the tubing opposite the upper perforations.

A variation of the parallel-tubing completion consists of two different size production tubing strings with the larger tubing continuous through the lower packer. The small tubing joins the large tubing at the upper packer so that the production may be crossed over as in Fig. 3-B to limit either zone's production to the proper-size tubing. The landing nipple and circulating valve are placed in the larger tubing.

Fig. 3-C is a type of dual completion using two small tubing strings clamped to the production tubing. With this completion one tubing is used for power oil to power hydraulic pumps and two tubings are used for each zone's production. The annulus is used as a gas separator for the upper zone. A landing nipple in the large tubing above the junction of the smaller tubing strings is all that is necessary to permit wire-line workovers of the zones below the lower packer.

Workovers. Permanent-completion remedial operations may be performed on the lower zone of parallel-tubing-type duals as if the well were completed as a single producer. One well of this type, deviated from an offshore platform, was reworked by the wire-line method. The tubing extension was used to wash out sand, cement the perforations, seal a channel, and Sandlock[e] the well. The upper zone was allowed to flow during the entire workover. Fig. 3-D illustrates a workover of this type.

When different-size tubing strings are used for production tubing, the small tubing may be used as a circulation string, or the annulus may be used for circulation if two packers are used in the installation. These workover techniques are shown in Fig. 3-C and 3-D.

A workover was recently performed on a dual well completed with a string of 2-in. production tubing and two small strings clamped to the production tubing. On previous occasions, sand had been removed from the lower zone of this well with the retrievable tubing extension. To exclude sand production from this well the tandem hydraulic pumps were circulated to the surface, and the standing valves were retrieved with a wire-line. One of the small tubing strings was used as a circulation path in place of the annulus. The lower end of the extension was located below perforations when the extension was in place, and the production tubing and smaller tubing strings were circulated with crude oil.

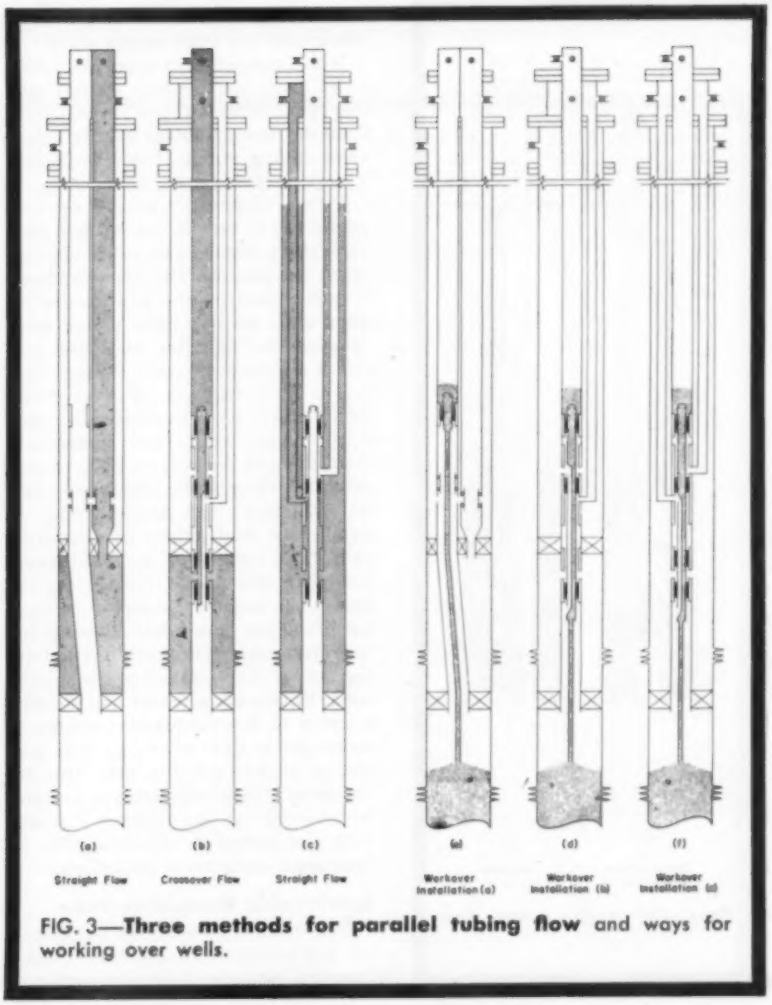

FIG. 3—**Three methods for parallel tubing flow** and ways for working over wells.

Plastic-coated walnut hulls were circulated down the production tubing and through the extension to a point opposite perforations and were then bradenhead-squeezed through the perforations to allow the hulls to screen out in the cavity behind the perforations and to completely fill this cavity and perforations. When the increase in squeeze pressure occurred, indicating that the perforations were filled, the excess hulls were reversed from the well. Sufficient time was allowed for the plastic to set, and the extension was retrieved. After rerunning the standing valves, the hydraulic pumps were again circulated into position and the well was placed on artificial lift. This was the first instance in which the Sandlock process was used with tubing extension on a dually completed well. However, the technique is no different from a single-well installation. The ability to eliminate drilling mud and to have the well tubing and Christmas tree in place so that surface pressures may be controlled when crude oil is used makes the permanent-completion technique with either dually or singularly completed wells the perfect type completion for the Sandlock sand-exclusion process.

Artificial Lift. The problem of artificial lift has been simplified by the use of parallel tubing strings. Fig. 4-A shows the most elementary way to gas lift by the suspension of small tubing in each independent production tubing string.

Retrievable gas-lift valve mandrels with minimum outside diameters such as the sleeve-type mandrel have been successfully run in each independent production tubing string. When this method of artificial lift is utilized, the casing annulus is used as a common gas-lift gas source. Although continuous and intermittent-type gas-lift operations have been carried on simultaneously with pressure-operated valves, the use of a common gas source highlights the need for efficient fluid-operated or tubing pressure-controlled gas-lift valves.

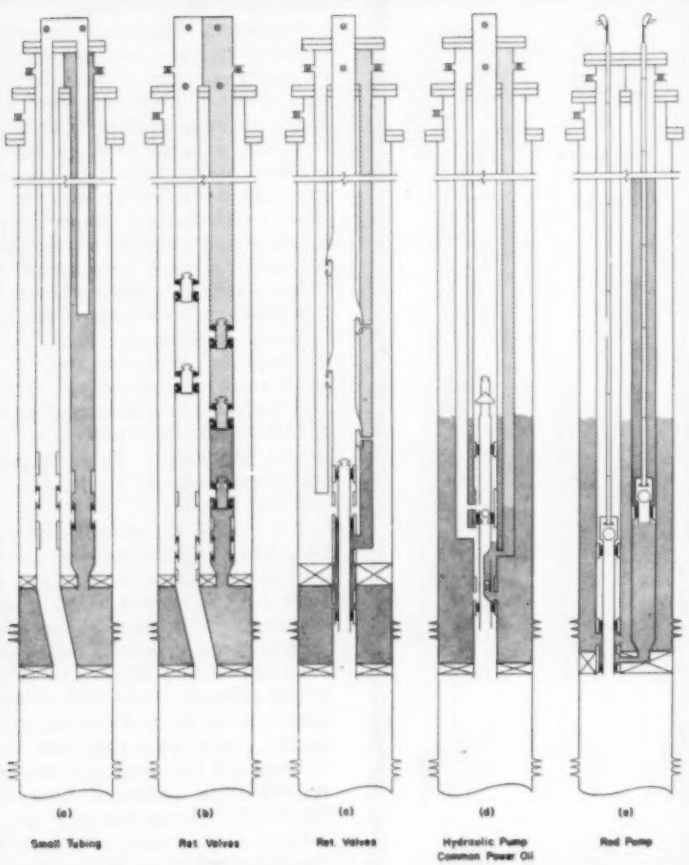

FIG. 4—**Methods of parallel tubing flow** with various means for artificial lift.

Such fluid-operated gas-lift valves should make practical the simultaneous gas lifting of both zones by intermittent-type operation. The use of sliding sleeve, retrievable gas-lift valve mandrels on each string of production tubing is illustrated in Fig. 4-B. Recent design changes have made practical the use of offset-type retrievable gas-lift valve mandrels in installations of this type. The offset mandrels may be run independently if certain restrictions are met. As an example, when using two strings of 2-in. tubing in 7-in. casing, the offset mandrels permit full-opening tubing to the lower zone but slightly restricted opening to the upper zone. The use of 1½-in. tubing to the upper zone or the use of smaller valves in the 2-in. tubing to the upper zone in this installation would permit full-opening production tubing to both zones.

The independent gas source gas-lift-type completion, shown in Fig. 4-C, requires that the production tubing be clamped together. This uses the same offset-type mandrel previously illustrated with tubing and annulus flow paths. However, here the porting is such that production is up the large tubing and one small tubing string.

In this manner, both upper and lower zones have independent gas-lift gas sources to alternate gas-lift mandrels from the casing annulus and the other small tubing string. This installation leaves one tubing string full-opening.

Either hydraulic pumps or rod pumps can be used in independent parallel-tubing installations or in tandem pump installations. The use of hydraulic subsurface pumps is attractive in some areas because these pumps may be connected together as a unit and utilize a common power supply. Fig. 4-D is an installation of this type in which power oil is pumped down one small tubing string and production from the two zones is produced independently through the large tubing and an additional small tubing string. A number of installations of this type have been completed with additional flexibility that allows both hydraulic pumps connected in tandem to be used for lifting one zone while allowing the other zone to be flowed up the one tubing string. An installation commonly used by some operators and readily adapted to the permanent-completion technique is that of the parallel rod pumps as shown in Fig. 4-E. This installation utilizes rod pumps as a means of artificial lift and requires that the rods and pumps be retrieved prior to permanent-completion operations.

Retrievable Production Tube

The success of wire-line workovers of permanently completed duals, coupled with the ability to perforate

the lower zone in the presence of clean fluids, created demand for a type dual that would permit these same features when dealing with the upper zone. This need became urgent when making dual completions in fields where surrounding locations or terrain made the use of rigs objectionable or very costly.

As a result, seven wells have been completed as duals which permit permanent-completion operations on both upper and lower zones. This was accomplished by making the tubing opposite the upper zone retrievable with a wire-line. A schematic illustration of this retrievable production tube is shown in Fig. 5-A. It was desirable to tube all production because of well characteristics, and limited casing size required the use of 2-in. and 1¼-in. parallel production tubing.

Two packers were used to isolate the common gas-lift gas from the upper-zone production. The lower drillable packer is equipped with a polished bore of landing-nipple dimensions, and the upper packer contains the junction of the two production tubes. This joining of production tubing is necessary to permit crossover operations. The upper end of the production tube is suspended and sealed in a landing nipple above the upper packer. The lower extremity of the tube contains chevron packing and seals in the drillable lower packer.

A safety joint is contained in the tube above the packing section so the tube will be parted at this point should the packing stick or be sanded in place. The retrievable production tubes now installed are constructed of extra heavy 1¼-in. pipe. Flush-joint connections are used to facilitate removal if this tube is surrounded with sand. In actual practice, when production tubes have been retrieved, the safety joint has generally parted and a second trip with wire-line tools has been necessary to retrieve the packing section.

Occasionally, small quantities of sand were encountered around the packing section, causing the safety joint to part. However, the safety-joint shear pins were initially made too small so that the safety joint parted as a result of packing friction alone. This shear-pin difficulty has been cured, and the tubes have been retrieved as a complete unit when not surrounded by sand.

A crossover choke, when necessary, may be built into the retrievable tube.

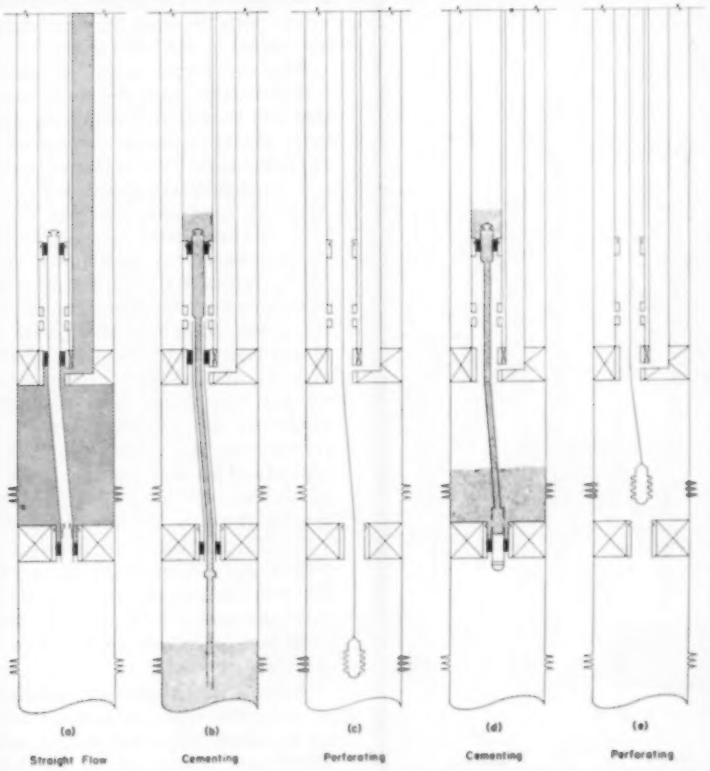

FIG. 5—**Use of retrievable production tube** in parallel tubing installations.

One well is now completed for crossover flow.

The lower zone of a dually completed well of this type has been reworked with a wire-line to remove sand, to cement, and to perforate. To rework this well, the production tube was retrieved, gas-lift valves were exchanged for dummy valves, and a tubing extension was seated in the landing nipple above the upper packer. To isolate the upper zone, the tubing extension was constructed of concentric pipe through the section between packers. For this 2-in. tubing installation, the concentric extension section was made of 1¼-in. and ¾-in. aluminum pipes. The larger pipe contained chevron packing elements to seal in the side-port nipple below the port to the annulus and in the drillable packer. This setup, shown in Fig. 5-B, isolated the upper zone and provided the two flow paths necessary for circulation between packers. After cementing, the tubing extension was removed, and a tubing-type perforator was run through the 2-in. tubing and drillable packer and was used to perforate the lower zone as shown in Fig. 5-C.

Workover of the upper zone of a well completed in this manner has not been necessary as yet. Such a workover may be accomplished, however, by placing a plug in the landing nipple machined into the bottom packer and by lowering an extension into place with the lower end of the extension positioned immediately above the plug. Equipment has been designed and tested, however, that permits the plug for the lower packer to be run on the extension. The perforations in the extension above this plug are covered until the entire assembly is pressure-tested. With this device, the extension and plug may be removed in one operation. Fig. 5-D shows the extension in place for cementing or sand-exclusion operations on the upper zone.

The upper zones have been perforated with the tubing gun on several occasions as illustrated in Fig. 5-E. In each instance it was necessary to dissolve the gun case with caustic soda prior to replacing the production tube. It is interesting that sand-production problems have not been experienced since perforating the upper zones in clean water as compared to previous wells in which the tubing was sand-cut opposite the upper zones when drilling mud was used as a perforating fluid.

In five of the wells presently completed, retrievable offset-type gas-lift valve mandrels are used for artificial lift. The 1¼-in. and 2-in. tubings pass through each mandrel, and the valves are retrievable through the 2-in. tubing. This is the same offset mandrel previously illustrated, only the two

small conduits through the mandrel are merged in common end connections to the 1¼-in. tubing. Fluid-operated gas-lift valves lift the production through 1¼-in. tubing, and pressure-operated valves lift production through the 2-in. tubing. Fluid-operated valves have performed satisfactorily to date and allow more efficient use of a common gas-lift gas source.

The simplicity of the retrievable production tube makes its use applicable in almost any type of permanently completed dual. Artificial-lift equipment is not altered; only the tubing opposite the upper zone is made retrievable. Although only the seven previously mentioned wells have been completed in this manner, Fig. 6-A and 6-B illustrate the installation of this tube in a single-tubing and a parallel-tubing well. When 2½-in. or larger production tubing is used, the retrievable production tube may be made of 1½-in. tubing. Minor modifications in the production tube hanger will then permit the passage of 1½-in. tubing tools as shown in Fig. 6-C and 6-D. In this situation the production tube may remain in place during lower-zone workovers.

Present Development

The advantages of independent parallel tubing strings, independent artificial-lift apparatus, and retrievable production tube, coupled with the presence of old wells having 5½-in. casing which could be recompleted as duals, created a need for a slightly different dual installation which would combine all the previously mentioned advantages. One and one-half-inch tubing was selected as the optimum-size tubing since two strings of this size could be successfully run in 5½-in. casing. Previous work on slim-hole completions had proved that it was possible to gas lift over 700 bbl per day of salt water from a 5000-ft deep high-fluid-level well with 1½-in. tubing. A special drillable lower packer, retrievable upper packer, and retrievable gas-lift valve mandrels were designed to permit their use in this type dual completion.

After the equipment was constructed and tested, a well was completed in this manner to evaluate the use of 1½-in. tubing, fluid-operated retrievable gas-lift valves, and wire-line recompletion operations on both upper and lower zones. Fig. 7-A shows this installation as set in a 5000-ft well. The use of 1½-in. tubing prohibits the use of concentric by-pass between packers while reworking the lower zone. Therefore, the lower drillable packer was constructed with two receptacles to receive the packing elements on the lower end of an extension run through each tubing string.

While producing the well, the retrievable production tube is suspended and sealed in one tubing string and the lower end is sealed in the lower packer to conduct production from the lower zone. A plug is then run through the other tubing string and sealed in the lower packer to fully isolate the upper and lower zones of the dual completion. Should sand production be experienced, a tubing extension with telescoping joints may be run through the tubing open to the upper zone production. By opening a communication port immediately above the upper packer in this tubing string, the sand may be removed by reverse circulating while pumping into the casing annulus. This would leave the upper zone clean to permit removal of either the plug or the retrievable production tube. When workover operations of the lower zone are performed, one extension is run through the lower packer and sealed in this packer. The second extension is run through the other tubing string and also sealed in the lower packer.

The use of two extensions provides sufficient flow paths for fluid circulation and completely isolates the upper zone during workover operations on the lower zone. This workover installation is schematically shown in Fig. 7-B. After all operations utilizing the tubing extension have been performed, the extensions may be retrieved and a 1⅜-in. OD tubing-type perforator may be run through the tubing and through the lower packer to reperforate the proper interval for lower-zone production. As yet, no workover operations of this type have been performed. However, the extension and lower packer plug have been run and retrieved and pressure-tested to prove the practicality of this operation. The bore passing through the lower packer is 1 7/16-in. ID, while the bore for the plug is only 1¼-in. ID so that each of the two receptacles are selective by their difference in diameters. Provisions have also been made for an upper-zone workover.

Possibly the simplest method for reworking the upper zone is the use of an extension suspended in one tubing string and sealed off in the lower packer with a perforated section immediately above the packing and a plug in the other receptacle of the lower packer as shown in Fig. 7-C. It is pos-

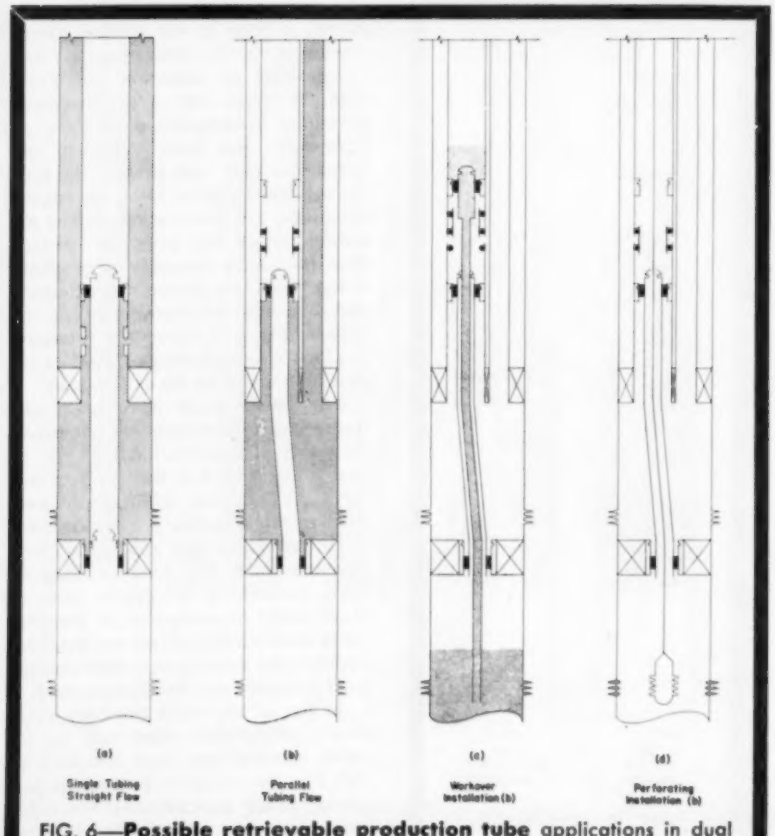

FIG. 6—**Possible retrievable production tube** applications in dual installations.

sible also to again run two extensions, both sealing in the lower packer and one having a perforated section above the lower packing and the other having a perforated section at the top of the extension. With either upper or lower-zone workover, both production tubing strings may be used as flow paths, and the casing annulus may be left sealed.

As soon as adequate artificial-lift tests have been performed to evaluate simultaneous gas lifting of both zones under a variety of conditions, both upper and lower-zone workovers will be performed to evaluate these operations.

At the present time the upper and lower packers are separated by approximately 25 ft. This distance will be increased to approximately 200 ft in the later stages of these testing operations to prove the practicality of this greater distance between packers.

Summary

The experiences with permanent-type dual completions have been good. Increased success and familiarity with the permanent-completion technique in general, and duals of this type in particular, have caused a trend to completion of all duals to allow wire-line workovers of one or both zones. Experience with installation and wire-line workovers of permanently completed duals during recent years has led to the following observations:

1. A substantial cost advantage may be gained through wire-line workover of permanently completed duals. The remedial costs are equal to or only slightly greater than single-completion wells, while conventional workovers are generally much greater with dual completions thereby allowing a greater percentage reduction in workover costs. Remedial operations, to date, with through-the-tubing tools on dual completions have consisted of cementing, perforating, sand removal, sand exclusion, and formation stimulation.

2. A large majority of duals may be completed in a manner to permit through-the-tubing tools if the conditions of relatively full-opening tubing, landling nipple for tubing extension, pressure-tight tubing to top of landing nipple, circulation port below landing nipple, and ability to isolate upper zone are incorporated.

3. The recent trend in dual completions seems to be directed toward the use of parallel tubing strings because of versatility and ability to isolate well production to tubing. Rod pumps, hydraulic pumps, and gas-lift valves may be successfully used as artificial-lift means with this type dual. The desirability of keeping the number of tubing strings to a minimum favors use of a common gas source for gas lifting and makes fluid-operated gas-lift valves increasingly attractive.

4. Initial success and extreme versatility of the retrievable production tube show great promise for this type of installation. Although as yet not utilized to its fullest capacity, this retrievable production tube permits use of all wire-line techniques on the upper zone now presently being used on the lower zone in permanent-type dual completions. It is anticipated that comparable cost reductions will be effected. The retrievable production tube may be used in practically any type of dual installation to replace permanent tubing opposite the upper zone provided one string of production tubing is full opening. Initial results would seem to indicate that perforating the upper zone of a dual in the absence of drilling mud may eliminate or reduce to a great extent the amount of sand cutting or erosion of the tubing opposite this upper zone.

5. Present development work needs to be continued on a method of dually completing two zones with parallel strings of 1½-in. tubing inside 5½-in. casing. The availability of through-the-tubing tools for use with 1½-in. tubing in slim holes makes this type of dual completion extremely practical.

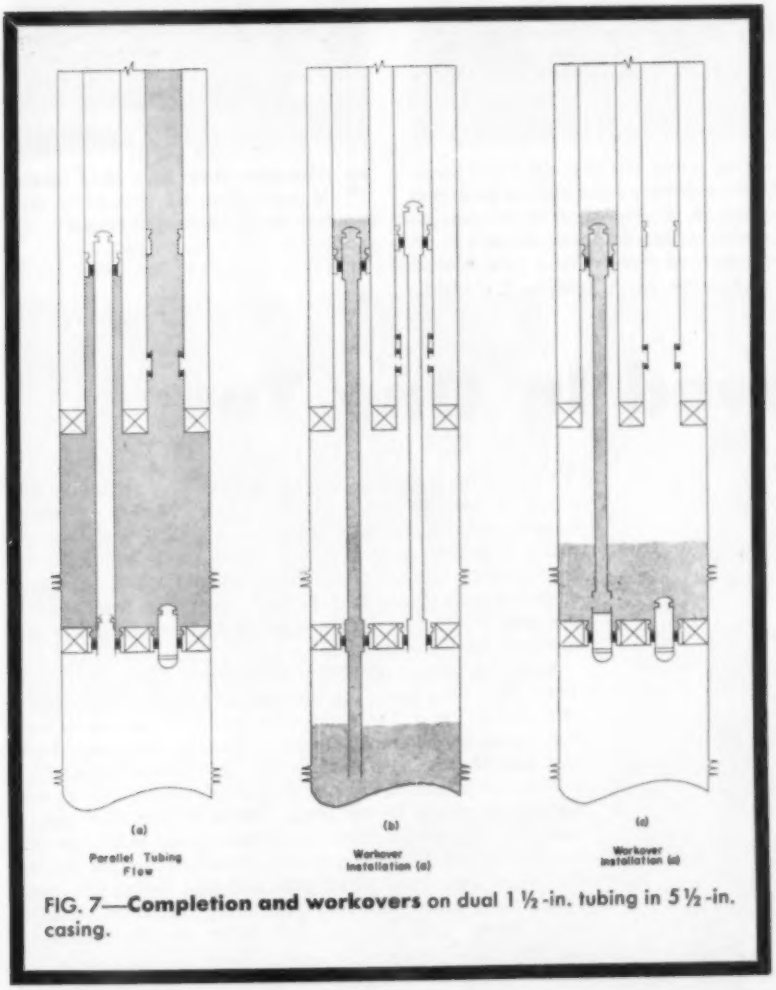

FIG. 7—**Completion and workovers** on dual 1½-in. tubing in 5½-in. casing.

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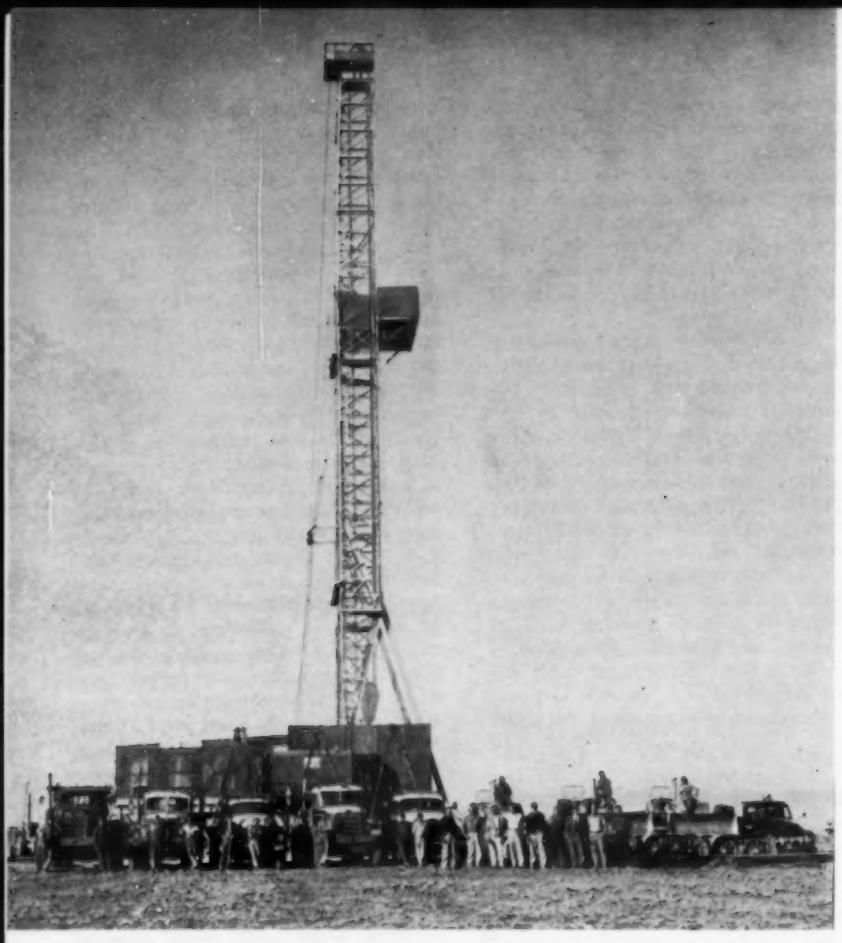
Less than eight hours from tear down to rig up in one-half-mile move in New Mexico



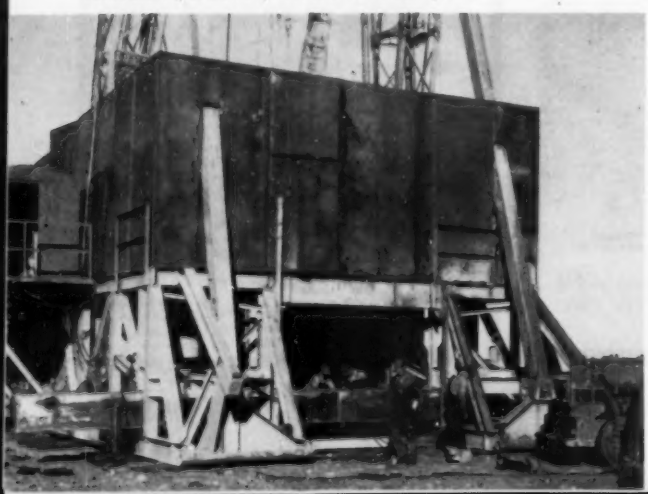
1 Rig, crew and equipment. The crew that made this fast rig move were: Rumbaugh supervisor H. Gene Powell, Durham drilling superintendent Bill Hall and tool pusher Neil Lauderback, rig builders, B. R. Powell, J. P. Rumbaugh, John Brokat, A. M. Cree, W. W. Overall, and D. L. Morland, cat skinners E. M. Samaniego, E. C. Maxwell, and H. L. Taylor, and truck drivers Travis Cox, Roland Chandler, Tex Berry, J. D. Poyner, Bobbie McKammie, G. A. Jenkins, E. C. Addison, George Poyner and Bill Smith.

2 Massive steel box skid beam is readied to be placed in skid window made into rig structure.

P 422.142.

Big Rig Moved In One Tour

3 Powerful hydraulic jacks are placed into position along the box skid beam. Power pump truck at right controls hydraulic pressure to each jack.

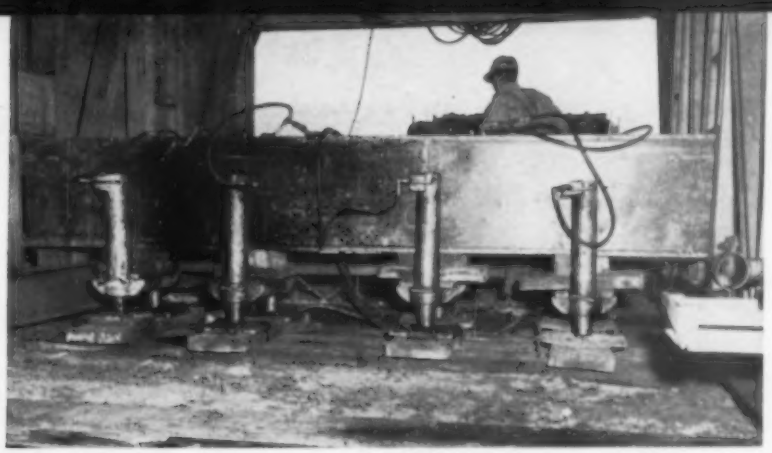


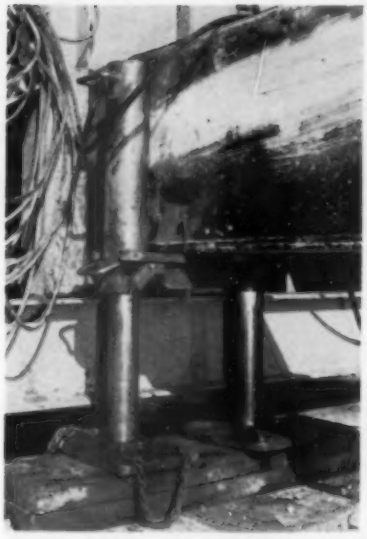
TYPICAL of unusually fast rig moves today across the flat plains of New Mexico is the step-by-step picture story that follows. A big heavy-duty power rig was torn down, moved half a mile and rigged up in less than eight hours. Secret of this fast move is to be found in the know-how and teamwork of the crews and in the fact that the substructure was designed for such a move without making it necessary to dismantle much of the equipment.

Rumbaugh, Inc., oil field trucking contractors of Odessa, Texas, made the move for Durham Drilling Company, Inc., of Midland, Texas. The rig moving specialists teamed up with the drilling crew to move Durham's Rig No. 4 to a new location near Hobbs, New Mexico. The rig, an Ideco Super 7-11 with a 143-ft mast, and capable of drilling to 15,000 ft, was moved practically in one piece. The two main mud pumps were the only major items of equipment that had to be disconnected and hauled separately. Other equipment carried by trucks was: Mud tanks; pipe and pipe racks; fuel tank; water tank; water, fuel and mud lines; tool house; standby mud pump and engine, and other smaller accessory equipment.

The substructure was so designed that two massive 40-ft

4 **Four sets of hydraulic jacks** straddle middle of massive box steel skid beam. A set of jacks is placed at either end of beam, totaling six sets per beam.



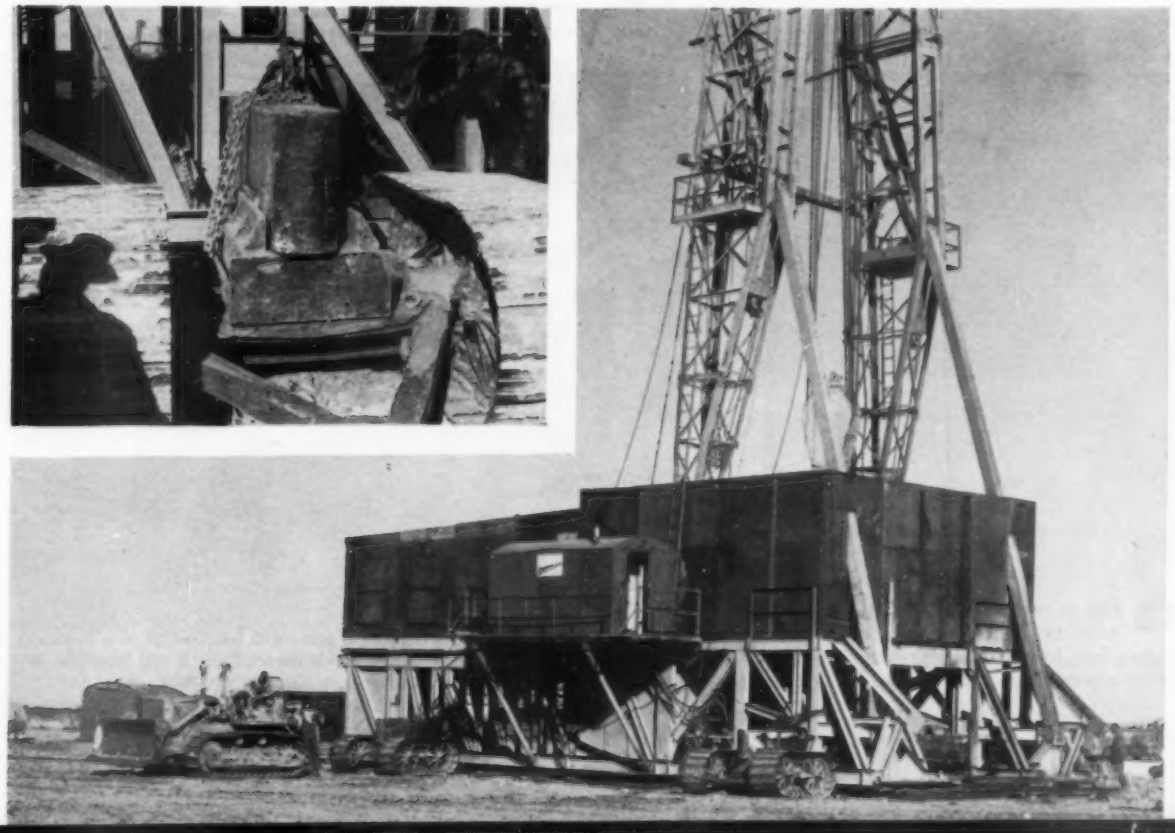


5 **Close-up of hydraulic jack** near end of beam. Note hydraulic hoses connected to jack to control raising and lowering of beam. Rig is in raised position.

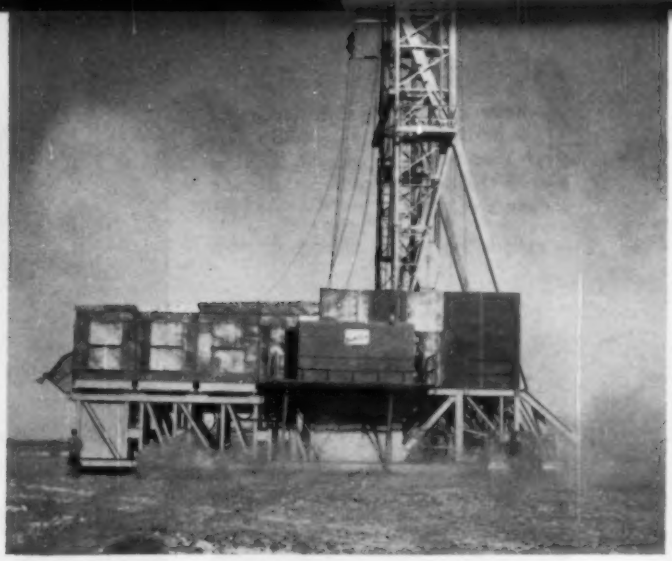
6 **Athey wagon backed into position** to accept beam and support weight of the rig. Beam is high enough to clear center section of wagons.

7 **Skid beam is chained down** to Athey wagon. Beam is securely wedged into the channel frame of the wagon to eliminate movement and help hold beam in place.

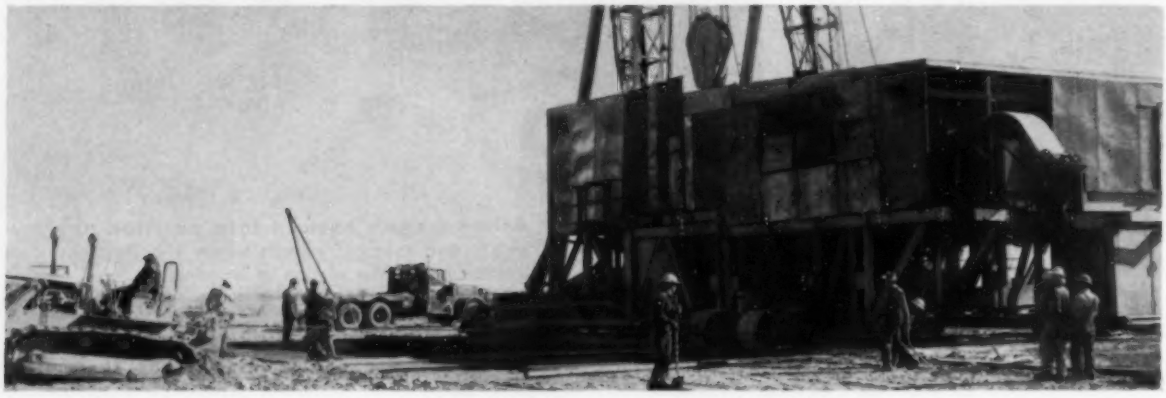
8 **All wagons in position** and jacks support entire rig, as tractor ties onto tongue of one wagon. Rig is nearly ready to "roll."



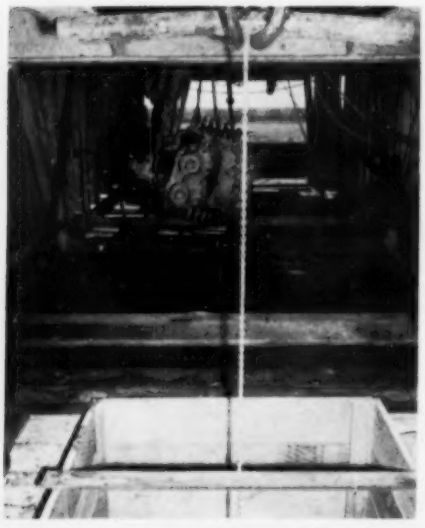
9 **Long spreader bar** connects to the tongues of the two leading Athey wagons to keep them aligned during the move. Cats tie onto each end of this bar.



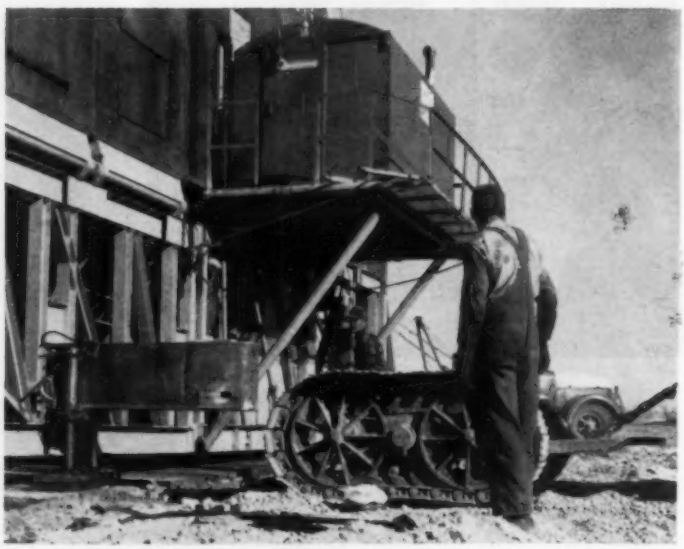
10 **Durham's big rig on the move** across the New Mexico plains near Lovington, leaving a trail of dust behind, indicating speed of movement.



11 **Rolling onto new location.** With both cats "dug in," rig is winched carefully onto board mats that have been levelled out before move.



12 **Rig is aligned over cellar** of new location. Half-inch chain serves as plumb bob to center rotary over center of cellar already dug and boarded up.



13 **Removing Athey wagons from skid beams** at new location. Jacks were employed in the same manner as at old location. Rig is now ready to be lowered.

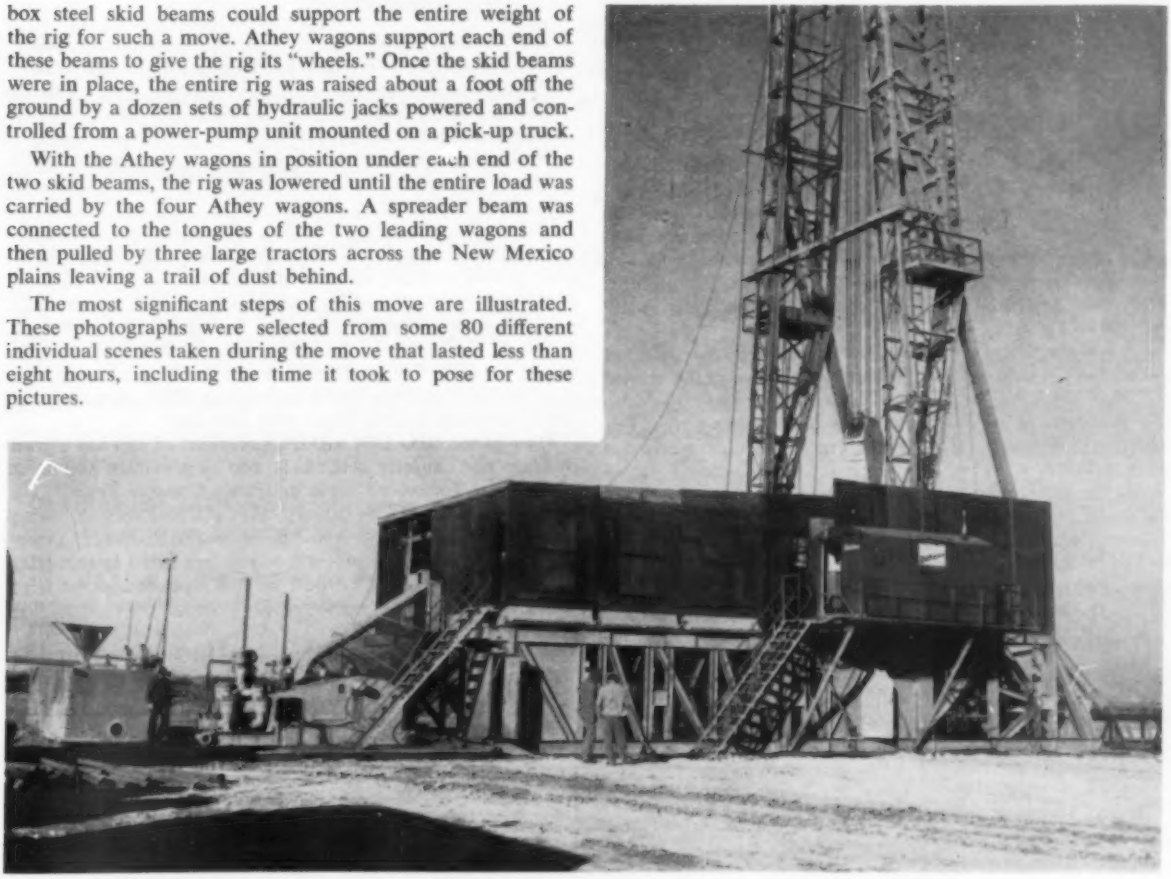
14 **Skid beams pulled from substructure** by tractor after rig was lowered onto boarded foundation by hydraulic jacks, which were removed.

15 **Mud pump positioned on board mat** especially prefabricated for a unitized foundation. Truck backs pump in place, slacks off winch and drives forward.

box steel skid beams could support the entire weight of the rig for such a move. Athey wagons support each end of these beams to give the rig its "wheels." Once the skid beams were in place, the entire rig was raised about a foot off the ground by a dozen sets of hydraulic jacks powered and controlled from a power-pump unit mounted on a pick-up truck.

With the Athey wagons in position under each end of the two skid beams, the rig was lowered until the entire load was carried by the four Athey wagons. A spreader beam was connected to the tongues of the two leading wagons and then pulled by three large tractors across the New Mexico plains leaving a trail of dust behind.

The most significant steps of this move are illustrated. These photographs were selected from some 80 different individual scenes taken during the move that lasted less than eight hours, including the time it took to pose for these pictures.



16 **Ready for action on new location** in less than eight hours. Auxiliary equipment not carried by the unitized substructure is unloaded and hooked up. The end of a fast rig moving job.

THE PETROLEUM ENGINEER'S "Spring"

DRILLING RIG LOCATOR

The second comprehensive directory of contract drilling rigs in the United States and Canada. Here's what is contains:

- **Contractor's name and address.**
- **Rig number, name and type.**
- **Type fuel used.**
- **Make and model of drawworks.**
- **Total horsepower of all main mud pumps.**
- **Drilling depth with 4½-in. pipe.**
- **State and county location.**

This is the second time in the industry's history that a directory of contract drilling rigs has ever been published. In its October, 1955, issue, *The Petroleum Engineer* undertook the first such directory every published. Responses from oil operators and drilling contractors alike was more than expected, and the second, *PE's "Spring" RIG LOCATOR*, is published in compliance with the wishes of a large segment of the drilling industry.

As was expected, many recommendations for the improvement of the original directory were made. From operators and contractors came ideas to incorporate in the second undertaking. Once the need was established for such a directory, the editors have merely attempted to carry out the many valuable suggestions made by those who use the directory and those who supply the data.

One main point we wish to establish was the frequency of such a directory. Based on the expressed opinions of both users and contractors, a four-month interval was established. The second *RIG LOCATOR* proved the validity of such a period between directories. In many cases, it was found that although rigs did move from one location to another, it was the exception that they moved entirely out of the geological province in which they were working. In most cases, rigs moved to adjacent counties, or remained in the same counties. Since it would be difficult to satisfy all cases, it has been decided to publish the *RIG LOCATOR* every four months. They shall be called PE's "Spring," "Summer," and "Fall" directories.

Several operators and contractors suggested that the total horsepower of the main mud pumps be included in the second RIG LOCATOR. This has been done, and we hope it adds to the value of the directory and aids in evaluating rigs. For exact identification purposes, the rig number or name has been included.

Among the most prominent suggestions was that of listing the make and model of the drawworks. We have done this. To save space in the directory, some acceptable abbreviations had to be used. Some are well known; others not. Here's the code employed:

Manufacturer's Company Name	Abbreviation
Beaumont Iron Works Co. (Div. of American Locomotive Co.)	BIW
Bethlehem Supply Co.	Beth
The Brewster Co., Inc.	Brewstr
Bucyrus-Erie Co.	B. Erie
Cardwell Manufacturing Co.	Cardwell
Fred E. Cooper, Inc.	Cooper
Emsco Manufacturing Co.	Emsco
George E. Failing Co.	Failing
Franks Manufacturing Corp.	Franks
Ideco (one of the Dresser Industries)	Ideco
Mayhew Supply Co., Inc.	Mayhew
The National Supply Co.	Natl
Oil Well Supply Div. (U.S. Steel Corp.)	Oil Well
Texas Iron Works, Inc.	TIW
Unit Rig & Equipment Co.	Unit
Wagner-Morehouse, Inc.	Wgnr-Mrhse
Walker-Neer Manufacturing Co., Inc.	Wklr-Neer
The Wheland Co.	Whlnd
Wichtex Machinery Co., Inc.	Wichtex
Wilson Manufacturing Co., Inc.	Wilson

Other abbreviations include: Steam — stm; gasoline — gaso; butane — btne; diesel — dsl; propane — prop. In most of the rigs listed, the drilling depth is rated with 4½-in. drill pipe. However, in a few instances, the rig is rated with 3½- or 2⅞-in. drill pipe. In the latter case, the drill depth will be shown as 7500/2⅞ or 6000/3½. In the case of cable tool rigs, this rated drilling depth is shown as 9000, meaning that this is the rated drilling depth with wire line.

How to use RIG LOCATOR. Locations of rigs are shown by states and counties in the U.S., and by provinces and areas in Canada. To located a rig in Harris County, Texas, look under Texas and Harris County. You will find only the name of the drilling contractor listed. In the alphabetical directory below, all contractors whose rigs are listed in this **RIG LOCATOR** are given. Purpose of this alphabetical list is to provide the current home office address of the drilling contractor involved.

Suggestions Wanted. Purpose of the **RIG LOCATOR** is to

Drilling Rig Locator Issues Available

This directory of contract drilling rigs will be revised and published every four months. To obtain this and future issues of THE PETROLEUM ENGINEER featuring the industry's only Drilling Rig Locator, use order form on page B-92.

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facilitate the location of rigs by operators who are seeking bids for drilling contracts. It was called to our attention that one contractor in Oklahoma attributed two contracts in the past four months to the first **RIG LOCATOR.** If you have any suggestions to improve the usefulness of this directory, you are cordially invited to send both your comments and suggestions to the Editor, THE PETROLEUM ENGINEER, P. O. Box 1589, Dallas 21, Texas.

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Nye & Snell Drilling Co.
260 Denver Club Bldg.
Denver, Colorado

The Oil Corp.
836 Wilson Bldg.
Corpus Christi, Texas

Bob Olds Drilling Co.
P. O. Box 113
Casper, Wyoming

L. H. & S. A. Olson Drilling Co.
Box 1545
Midland, Texas

W. B. Omohundro
P. O. Box 774
Wichita Falls, Texas

Orm Drilling Co.
421 M&P Bank Bldg.
Sherman, Texas

The Overby Drilling Company
411 W. Shawnee
Nowata, Oklahoma

Owen Drilling Co.
Oil Center Station
Lafayette, Louisiana

Paco Petroleum Corp.
Box 347
Mt. Carmel, Illinois

Pan-Tex Drilling Co.
316 Henderson Blvd.
Kilgore, Texas

Patco Drilling Contractor
Box 322
Stillwater, Oklahoma

Pennant Drilling, Ltd.
203 Mayo Bldg.
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Pep Drilling Co.
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With low density, low water loss DIACEL cements you can rotate and reciprocate the casing to minimize channeling. You encourage a better bond between pipe and hole. Versatile DIACEL systems can be formulated with cement densities ranging from 10.5 to 17 pounds per gallon to suit requirements of wells of all depths and temperatures.

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Pontiac Drilling Co. of Texas
1111 Oil & Gas Bldg.
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Fred Pool Drilling Co.
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Pool & Gerlich Drilling Co.
Box 1149
San Angelo, Texas

Porter Drilling Co.
317 Oil Capital Bldg.
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Powell Drilling Co.
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The Power Rig Drilling Co.
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Pyramid Drilling Co.
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Rocket Drilling Co.
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Rocky Mountain Drilling Co.
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Dwight M. Ross Drilling Co.
Hamilton Bldg.
Wichita Falls, Texas

Don M. Rounds Drilling Co., Inc.
620 Colorado Bldg.
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Rowan Drilling Co., Inc.
Fair Bldg.
Fort Worth, Texas

B. L. Rucker Drilling Co.
Box 127
Mt. Vernon, Illinois

Rupp-Ferguson Oil Co.
523 Petroleum Bldg.
Wichita, Kansas

Paul Rutledge
Box 2239
Santa Fe, New Mexico

Sabine Drilling Co.
208 N. W. Second St.
Seminole, Texas

Sabre Drilling Co.
Hughes Bldg.
Cushing, Oklahoma

Salt Dome Production Co.
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San Joaquin Drilling Co., Inc.
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Santa Fe Drilling Co.
Box 310
Whittier, California

Scat Drilling Co., Inc.
Box 787
Drumright, Oklahoma

Schafer Drilling Co.
Liberty Bank Bldg.
Oklahoma City, Oklahoma

Schimmel Drilling Co.
2121 Alamo National Bldg.
San Antonio, Texas

Schlaikjer, A. L.
Box 761
Newcastle, Wyoming

Schulz & Brannan Drilling Co.
621 Staley Bldg.
Wichita Falls, Texas

A. B. See Drilling Co., Inc.
Petroleum Bldg.
Abilene, Texas

Service Drilling Co.
515 Kennedy Bldg.
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Shelley-Miller Drilling, Inc.
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Shulman Brothers
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Signal Exploration, Inc.
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Signal Oilfield Service
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Don Slape Drilling Co.
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Olney, Illinois

Perl Smith Drilling Co.
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Stice Drilling Co.
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Strain Drilling Co.
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The Sun Drilling Co.
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A. W. Thompson, Inc.
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213 Triangle Bldg.
Pawhuska, Oklahoma

Tom Jack Drilling Co.
105 W. Muskogee
Sulphur, Oklahoma

Transit Corp.
1516 Liberty Bank Bldg.
Oklahoma City, Oklahoma

Trans-Tex Drilling Co.
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Shreveport, Louisiana

Trant Drilling Co.
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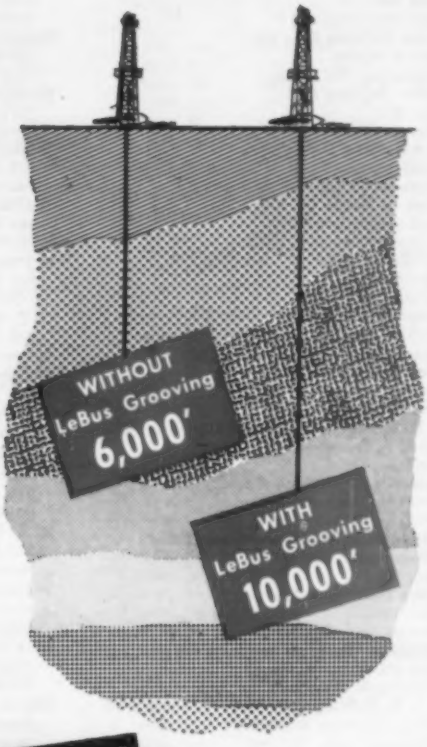
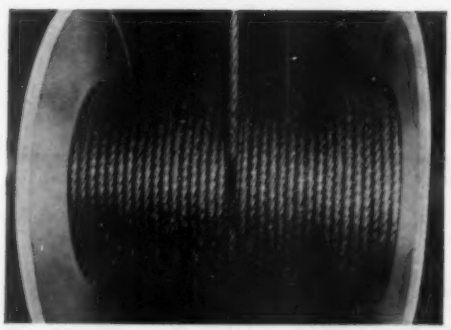
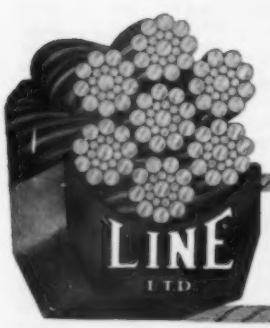
Correct Wireline Spooling Can Increase Rig Depth Rating!



LeBus COUNTERBALANCED SPOOLING DOES IT!



Write for full details. Ask about our trade-in policy for operators who have either the old style "Helical" or "Pyramid" Spooling system on their hoisting drums.



Illustrated above, on the left, is a two-engine rig capable of drilling wells to a depth of 6,000 ft. On the right is the same rig which has been equipped with a LEBUS COUNTERBALANCED SPOOLING SYSTEM and one more engine. Because of LeBus Spooling, the line will be properly controlled while being run at top speed and with the additional engine, its rated capacity has now been increased to approximately 10,000 feet.

In every case where LEBUS COUNTERBALANCED SPOOLING SYSTEMS have been installed, the drilling hoists are used more economically for up to 50% deeper drilling than the same size hoist with any other type of spooling. This medium additional cost is placing the users of LeBus Spooling Systems in a position to bid on deeper wells.

"Any method of spooling wire line as well as the LeBus method has to be a copy of LeBus Spooling."

Step up the depth rating of your drilling rig by installing the new LEBUS COUNTERBALANCED SPOOLING SYSTEM.

*LeBus Spooling methods are patented.

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Urice Drilling Co.
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Wagner & Wyant Drilling Co., Inc.
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Walker Brothers Drilling Contractors
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Walker Wilson Drilling Co.
509 Mile High Center
Denver, Colorado

Walton Drilling Co.
Box 241
Fairfield, Illinois

Warner & Luttrell Drilling Co.
Box 57
Effingham, Illinois

O. F. Warren Corp.
619 S. Detroit St.
Tulsa 3, Oklahoma

Warton Drilling Co.
Box 2807
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Dee Watson Drilling Co.
Mt. Carmel, Illinois

Carnes W. Weaver Drilling Co.
326 Gulf Bldg.
Houston, Texas

C. B. Webster Drilling Co.
San Jacinto Bldg.
Houston, Texas

Webster Drilling Co.
424 S. Cheyenne
Tulsa, Oklahoma

Dick Wegener, Drilling Contractor
1820 First National Bldg.
Oklahoma City, Oklahoma

Wells Drilling Co.
5382 Cherry Ave.
Long Beach, California

Wes-Tex Drilling Co.
308 Petroleum Bldg.
Abilene, Texas

West Central Drilling Co.
717 Citizens Bank Bldg.
Abilene, Texas

Wheless Drilling Co.
Box 368
Shreveport, Louisiana

Wilbanks & Rutter
2200 Scurry
Big Spring, Texas

Wilcox Drilling Co.
Box 365
Covington, Oklahoma

Kidd Williams Drilling Corp.
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Walter W. Willis
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Wilson Drilling Co., Inc.
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Jackson 5, Mississippi

Frank T. Wolfe
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Woolf & Magee
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Tyler, Texas

Yarborough Drilling Co.
419 Wilson Bldg.
Corpus Christi, Texas

Zapta Off-Shore Co.
2218 City National Bank Bldg.
Houston, Texas

Zephyr Drilling Corp.
1111 First National Bldg.
Tulsa, Oklahoma

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
ALABAMA					
Mobile County					
Zach Brooks Drlg Co	1	rotary, gas-dsl	Brwstr N-10	1100	11,000
	2	rotary, gas-dsl	Brwstr N-7	750	8,500
	8	rotary, gas-dsl	Brwstr N-95	1100	12,500
Drlg & Expl Co of Del Inc	35	rotary, gas-gaso	Emsco GB-800	1200	12,000
Trans-Tex Drlg Co	1	rotary, gas-btne	Natl 75 CA	920	10,500
ARKANSAS					
Jackson County					
Arkansas Oil Ventures Inc	1	cable, prop	Natl 3A6	.....	.....
Lafayette County					
Milton Crow Inc	5	rotary, gas	Brwstr N-7	600	7,500
Woolf & Magee Inc	10	rotary, gas-btne	Both Breeze	275	4,500/2⅞
Madison County					
Bennett Drlg Co	2	cable, LPG	Star 45	.....	4,000
Miller County					
Delta Drlg Co	8	rotary, stm	Ideco Sup Dty	750	12,000
Mercury Drlg Co	1	rotary, gas	Ideco H-20	200	3,500
Union County					
Milton Crow Inc	3	rotary, dsl	Brwstr N-4	520	5,000
Montgomery Drlg Co	2	rotary, gas-btne	Brwstr N-55	415	7,500
CALIFORNIA					
Fresno County					
Clyde Hall Drlg Co Inc	5	rotary, gas-btne	Emsco GB-800	1000	12,000
San Joaquin Drlg Co Inc	4	rotary, gas	Natl 75	1260	10,500
Glenn County					
Santa Fe Drlg Co	23	rotary, dsl	Ideco H-40	500	6,000
Kern County					
B & B Drlg Co	1	rotary, dsl	.....	278	2,500
	2	rotary, btne	.....	900	1,750/3½
	3	cable, btne	.....	.....	.....
	4	cable, btne	.....	.....	.....
Camay Drlg Co	2	rotary, gas	Wilson Titan	1080	12,000
Cassy & Montgomery Inc	A	rotary, dsl-gas	Emsco G-450	700	6,500
	B	rotary, gas-btne	Natl 75	800	10,000
	C	rotary, dsl	Unit U-15	450	6,000
Douglas Drlg Co	1	rotary, btne	Emsco	125	2,500
Green & Heiser Drlg Co	1	rotary, dsl	Oil Well 66	835	8,500
	2	rotary, dsl	Wilson Giant	675	8,500
John S. Hagestad Drlg Co	1	rotary, dsl	.....	550	7,000
	2	rotary, dsl	.....	540	4,500
	3	rotary, dsl	.....	625	7,000
	4	rotary, dsl	.....	680	7,500
Clyde Hall Drlg Co Inc	4	rotary, dsl	.....	300	5,000
Hylton Drlg Co	2	rotary, btne	Wilson, Sr.	85	2,500
	4	rotary, dsl	Gen Mach	100	3,500
Ivy Drlg Co	1	rotary, dsl	Hopper 1G	185	1,500
	2	rotary, btne	Hopper GF	185	3,000
	3	rotary, btne	Hopper GD	260	5,000
L&F Drlg Co	2	rotary, dsl	Emsco GB-250	500	5,000
Miller & York	A	rotary, dsl	Emsco GA-500	600	8,500
	C	rotary, dsl	Emsco G-36	300	5,500
	F	rotary, dsl	Emsco GB-350	450	7,000
	G	rotary, dsl	Emsco G-36	300	5,000
	H	rotary, dsl	Emsco GA-250	300	5,000
	J-10	rotary, dsl	Hopper Hst Cnt	210	3,500
Newton Drlg Co	1	rotary, dsl	Ideco H-30	300	4,000
	4-40	rotary, dsl	Cardwell 400	320	6,000
Rocky Mountain Drlg Co	2	rotary, gas	Natl 75	1200	11,000
	3	rotary, gas	Natl 100	1200	14,000
	4	rotary,gas	Oilwell 96	1400	20,000
	9	rotary, gas	Natl 125	1200	20,000
San Joaquin Drlg Co Inc	1	rotary,gas	Natl 75	700	9,500
	5	rotary, gas	Natl 125	1260	15 000
Santa Fe Drlg Co	9	rotary, gas-btne	Wilson Titan	180	9,000
Stanford & Martin Drlg Co	1	rotary, dsl	Ideco H-40	400	5,000
	2	rotary, dsl	Wilson Mgl 42	400	5,000
Kings County					
San Joaquin Drlg Co Inc	3	rotary, gas	Wilson S T 66	1260	15,000
Los Angeles County					
Camay Drlg Co	1	rotary, gas	Emsco J-1000	1075	12,000
	3	rotary, gas	Natl 75	855	9,000
	4	rotary, gas	Emsco 500	555	7,500
	5	rotary, gas	Natl 50	535	7,000
	7	rotary, gas	Emsco G-300	535	6,000
	8	rotary, dsl	Ideco H-30-TD	255	4,500

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Comet Drlg Co Inc	1	rotary, dsl	Franks Clpr	350	5,000
	2	rotary, gas	Unit U-36	625	8,500
Drlg & Expl Co of Del Inc	20	rotary, gas-gaso	Natl 100	1200	13,500
	31	rotary, gas-gaso	Natl 130	1500	18,000
Clyde Hall Drlg Co Inc	8	rotary, dsl	Both M-58	600	9,000
L&F Drlg Co	3	rotary, gas-dsl	Emsco 450	900	8,000
Macrate Prod Co	2	rotary, dsl	Idaco HD-30	175	3,500
	7	rotary, gas	Wgnr Mrhse	300	4,000
Rocket Drlg Co	1	rtry, gs-btne-prop	Emsco G-300	555	4,500
Rocky Mountain Drlg Co	5	rotary, dsl	Oilwell 96	1480	20,000
Santa Fe Drlg Co	7	rotary, gas-btne	Hopper Blitz	300	5,000
	19	rotary gas-btne	Natl 50	900	7,000
The Sun Drlg Co	2	rotary, gas	Natl 125	1400	15,000
	4	rotary, elec	Natl 110	750	15,000
Wells Drlg Co	1	rotary, dsl	Unit U-10	650	5,000
	2	rotary, dsl	Wldrp Blitz 622	325	4,500
Madera County					
Newton Drlg Co	2	rotary, dsl	Idaco H-40	320	5,000
Monterey County					
L & F Drlg Co	1	rotary, gas	Emsco GB-250	300	5,000
Orange County					
Camay Drlg Co	6	rotary, gas	Natl 50	605	7,000
Comet Drlg Co Inc	3	rotary, dsl	Natl 50	600	8,000
	5	rotary, gas	Emsco J-1000	900	13,000
Santa Fe Drlg Co	8	rotary, gas-btne	Wilson Giant	500	6,000
San Bernardino County					
Comet Drlg Co	4	rotary, gas	Natl 75	800	10,000
San Luis Obispo					
Santa Fe Drlg Co	3	rotary, gas-btne	Emsco GC-500	980	7,000
Santa Barbara County					
Clyde Hall Drlg Co Inc	7	rotary, dsl	Both M-58	900	10,000
Ventura County					
Drlg & Expl Co of Del Inc	13	rotary, stm	Natl 34-10	1500	17,000
	17	rotary, stm	Natl 34-10	1500	17,000
	23	rotary, gas-gaso	Natl 100	1000	12,000
	28	rotary, gas-gaso	Natl 50A	800	9,000
	29	rotary, gas-gaso	Natl 34-10	1500	18 000
Rocky Mountain Drlg Co	1	rotary, gas	Natl 75	1200	11,000
	6	rotary, gas	Emsco J-1000	1200	15,000
	7	rotary, gas	Natl 100	1200	15,000
	8	rotary, gas	Natl 125	1400	20,000
	10	rotary, gas	Emsco J-1000	1260	15,000
	12	rotary, gas	Natl 125	1480	20,000
	13	rotary, gas	Emsco J-1250	1200	20 000
	14	rotary, gas	Emsco J-1250	1200	20,000
	15	rotary, gas-dsl	Emsco J-750	1200	11,000
San Joaquin Drlg Co Inc	2	rotary, gas	Natl 110	1530	15,000
	6	rotary, gas	Natl 125	1260	15,000
Santa Fe Drlg Co	13	rotary, gas-btne	Wilson Titan	1000	9,000
The Sun Drlg Co	1	rotary, gas	Natl 100	1250	12,000
	3	rotary, gas	Natl 125	1500	15,000
United Drlg Co	1	rotary, gas	Emsco EDA	600	6,000
	2	cable, gas	Star 52	.....	6,000
COLORADO					
Adams County					
Cactus Drlg Corp of Texas	2	rotary, gas-btne	Unit U-15	300	8,500
Denver County					
L B Conner	1	rotary, gaso	Failing SS	165	2,500/3½
Gunnison County					
Wilcox Drlg Co	2	rotary, gaso	Failing 1500 ..	50	1,500/2⅞
Jackson County					
Big Horn Drlg Co Inc	3	rotary, dsl	.....	600	7,500
La Plata County					
Flooger-Riley Drlg Co Inc	4	rotary, gas	Unit U-15	320	8,000
Great Western Drlg Co	39	rotary, gas-gaso	.....	.....	5,000
H B Lynn Drlg Corp	2	rotary, gas-btne	Natl 50	700	7,500
Paul F Rutledge	4	rotary, gas	Both C-50	450	7,000
Las Animas County					
Danforth Drlg Co	1	rotary, dsl	Idaco H-30	240	5,000
Logan County					
Anschutz Drlg Co Inc	5	rotary, dsl	Wilson Giant	300	5,000
Baird & Pfeifer Drlg Co	1	rotary, dsl	Unit U-15	450	9,500
	2	rotary, gas	Unit U-15	300	7,500
Calvert Drlg Inc	Rep	rotary, dsl	Idaco H-30	240	5,000

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Creekmore Drlg Co	1	rotary, btne	Brwstr N-45	200	6,000
Exploration Drlg Co	1	rotary, gas	Both S-60	370	6 000
Garvey Drlg Co	18	rotary, dsl	Wilson Giant	300	7,500/2½
Miracle-Flfor Drlg Co	3	rotary, btne	.....	300	6,000
Don M Rounds Drlg Co Inc	1	rotary, dsl	Natl 50	350	6,000
Signal Oilfield Serv	2	cable, gas	Cardwell RL	.....	.....
	4	cable, gas	Cardwell RL	.....	.....
	5	cable, gas	Cardwell RL	.....	.....
	11	cable, gas	Cardwell RL	.....	.....
	12	cable, gas	Cardwell RL	.....	.....
	13	cable, gas	Cardwell RL	.....	.....
	14	rotary, gas-gaso	Franks S Clpr	.....	6,000/2⅞
Strain Drlg Co	1	rotary, dsl	.....	325	7,000
Walker Wilson Drlg Co	3	rotary, dsl	Natl T-32	320	6,000
Moffat County					
Carmack Drlg Co	5	rotary, gas	Natl T-32	400	6,000
Mesa Drlg Co Div of Camay Drlg Co	2	rotary, gas	Emsco GA-500	600	7,500
Mountain States Drlg Co Inc	3	rotary, gas-dsl	Natl 50A	600	7,500
Rowan Drlg Co Inc	24	rotary, gas	Natl 50	504	8,500
Montezuma County					
Exploration Drlg Co	4	rotary, gas	Unit U-15	625	8,000
Morgan County					
Calvert Drlg Inc	21	rotary, dsl	Idaco H-35	350	6,500
Carmack Drlg Co	4	rotary, dsl	Natl T-32	472	6,000
Delta Drlg Co	28	rotary, dsl	Franks SAL-6000	350	5,000
Exeter Drlg Co	1	rotary, dsl	Emsco GA 350	325	6,000
Falcon Seaboard Drlg Co	9	rotary, gas-btne	Unit U-15	325	8,500
	25	rotary, dsl	Both Twister	225	6,500
McCutchen & Graham	2	rotary, btne	Unit U-15	255	7,000
Nye & Snell Drlg Co	2	rotary, dsl	Wilson M-L16	250	6,000
San Miguel County					
Exploration Drlg Co	15	rotary, gas	Natl 75-CA	970	11,000
Washington County					
Brinkerhoff Drlg Co	23	rotary, dsl	Natl T-20	275	5,500
The Cortez Drlg Co	1	rotary, gas	Natl T-32	300	6,000
Falcon Seaboard Drlg Co	MA-1	rotary, gas-btne	Unit U-35	500	6,500
Garvey Drlg Co	2	rotary, dsl	Wilson Giant	300	7,500/2½
	16	rotary, dsl	Wilson Giant	300	7,500/2½
Zephyr Drlg Corp	12	rotary, dsl	Both S-45-E	250	4,000/2⅞
Weld County					
Dyer Drlg Co	2	rotary, gas-gaso	Oil Well 64B	325	7,000
Exploration Drlg Co	6	rotary, gas	Both S-50	350	5,500
Falcon Seaboard Drlg Co	16	rotary, gas-btne	Unit U-15	325	8,500
Signal Exploration Inc	1	rotary, gas	.....	500	8,500
FLORIDA					
Orange County					
Dorris Ballew Inc	3	rotary, dsl	Wilton Titan	760	15,000
ILLINOIS					
Bond County					
Calvert Drlg Inc	17	rotary, gas-btne	Idaco H-30	240	4,500
	18	rotary, gas btne	Unit U-15	350	8,500
	19	rotary, dsl	Unit U-15	350	8,500
	20	rotary, dsl	Idaco H-525	350	8,500
Claypool Drlg Co	R-1	rotary, btne	Natl T-20	145	4,500
	R-2	rotary, btne	Natl H-40	185	4,500
Murvin & Stober Drlg Co	1	rotary, dsl	Natl T-20	.....	5,500
J Frank Hinkle Drlg Co	1	rotary, dsl	Cardwell L	375	3,000
C W Strotman Drlg Co	2	cable, gas	Cardwell H	.....	.....
Clark County					
Donald P Knierim	3	rotary, gas	Failing 2500	180	2,500/3½
	4	rotary, gas	Failing 2500	180	2,500/3½
Clay County					
D B Lesh Drlg Co	4	rotary, gas	.....	450	7,000
Shulman Bros	1	rotary, dsl	Cardwell S-350	330	5,500
	2	rotary, dsl	Cardwell L	330	3,500
	1	cable, gas-gaso	Cardwell H	.....	4,000
	2	cable, gas-gaso	Cardwell, H	.....	4,000
Don Slape Drlg Co	1	rotary, dsl	Oil Well 64-A	260	5,000
	1	cable, btne-gas	Cardwell K	125	5,000
	3	rotary, dsl	Oil Well 64-B	260	5,500
Clinton County					
Conrey Drlg Co	1	rotary, gas	Wilson Super	140	2,000/3½
Coles County					
C W Strotman Drlg Co	1	cable, gas	Cardwell H	.....	.....
Crawford County					
Hoagland Drlg Co Inc	1	rotary, btne	Franks 2000	145	2,000/2⅞

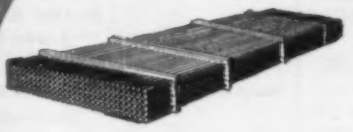
Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Walton Drlg Co	1	rotary, gas	Failing 2500	.....	2,000/3½
	2	rotary, gas	Failing 2500	.....	2,000/3½
		Edwards County			
Calvert Drlg Inc	12	rotary, dsl	Ideco H-30	260	4,500
The Noah Petroleum Co	1	rotary, dsl	Brwstr N-4	300	5,500
		Effingham County			
Claypool Drlg Co	C-2	cable, gas-gaso	B Erie 24-L	65	1,500
		Fayette County			
Claypool Drlg Co	C-1	cable, gas-gaso	B Erie 24-L	65	1,500
	C-3	cable, gas-gaso	B Erie 60-L	65	1,500
	C-4	cable, gas-gaso	B Erie 60-L	65	1,500
	C-5	cable, gas-gaso	B Erie 28-L	78	3,500
	C-6	cable, gas-gaso	B Erie 28-L	78	3,500
Donald P Knierim	1	cable, gas	B Erie 60-L	.....	.....
	2	cable, gas	B Erie 24-L	.....	.....
		Franklin County			
C E Brehn	2	rotary, dsl	Brwstr N-4	240	5,000
Delta Drlg Co	27	rotary, dsl	Emsco GA-350	380	6,000
D B Lesh Drlg Co	2	rotary, dsl	.....	320	5,500
Walter W Willis	2	rotary, dsl	Wilson Mogul	256	4,500
		Gallatin County			
Eakle & Holder Drlg Co	1	rotary, dsl	Brwstr N-4	200	5,500
	2	rotary, dsl	Emsco G-300	200	5,500
	4	rotary, dsl	Natl T-20	300	5,500
		Hamilton County			
Ardee Oil Co	1	cable, btne	B Erie 36-L	.....	5,000
	2	rotary, dsl	Emsco GB-350	.....	7,500
C E Brehn	4	cable, btne	Cardwell K	.....	.....
Pep Drlg Co	2	rotary, dsl	Ideco H-35	330	6,000
Walter W Willis	4	rotary, dsl	Ideco H-35	278	5,500
		Jasper County			
Calvert Drlg Inc	16	rotary, dsl	Ideco H-35	260	5,000
Don Slape Drlg Co	2	rotary, dsl	Unit U-34	240	4,500
		Jefferson County			
B L Rucker Drlg Co	1	rotary, dsl	Both 45-E	318	5,000
		Lawrence County			
Nation Drlg Co	3	cable, btne	.....	.....	4,000
		Marion County			
Conrey Drlg Co	2	rotary, dsl	Wilson Super	174	2,500/3½
		Richland County			
Calvert Drlg Inc	11	rotary, dsl	Natl T-32	260	5,000
Forbanta Drlg Co	1	rotary, gas	Cardwell	200	4,200
	2	rotary, gas	.....	225	5,000
		Saline County			
C E Brehn	1	rotary, dsl	Brwstr N-4	240	5,000
	3	cable, btne	Cardwell K	.....	.....
Gene Miller Inc	5	rotary, dsl	.....	300	.....
C W Strotman Drlg Co	4	cable, gas	B Erie 36	.....	.....
		Shelby County			
Don Slape Drlg Co	4	rotary, dsl	Unit U-34	240	4,500
		Wabash County			
Dee Watson Drlg Co	1	rotary, dsl	Cardwell RL	200	4,000
	2	rotary, dsl	Cardwell S	200	4,000
	3	cable, gaso	Cardwell H	.....	.....
		Wayne County			
Calvert Drlg Inc	8	rotary, dsl	Ideco H-30	260	4,500
Eastern Drlg Inc	1	rotary, dsl	Natl T-20	266	5,000
D B Lesh Drlg Co	3	rotary, dsl	.....	200	4,000
Nation Drlg Co	6	rotary, btne	.....	260	4,000
Pep Drlg Co	1	rotary, dsl	Both Breeze	330	5,000
		White County			
Calvert Drlg Inc	15	rotary, dsl	Ideco H-35	260	5,000
Forbanta Drlg Co	1	cable, gas	.....	.....	6,000
	3	cable, gas	.....	.....	8,000
Jack Hinkle	1	rotary, gas	Wilson	.....	3,500
	2	rotary, gas	Cardwell	.....	3,500
	3	cable, gas	Cardwell R	.....	3,500
Lauderdale Drlg Inc.	1	rotary, gas	Brwstr N-4	.....	4,500
Murvin & Steber Drlg Co	2	rotary, gaso	Natl T-12	.....	4,500
Nation Drlg Co	4	rotary, dsl	.....	.....	4,000
Paco Petroleum Corp	1	rotary, dsl	Natl T-32	320	6,000
	2	rotary, btne	Wilson Mogul	200	4,000
	3	rotary, dsl	Unit U-35	320	7,000

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
C W Strotman Drlg Co	3	cable, gas	Cardwell K	.....	.....
Walter W Willis	1	rotary, dsl	Both 430-S	278	4,500
INDIANA					
		Dubois County			
Highland Oil Co	1	cable, dsl	B Erie 24-L	.....	2,000
		Gibson County			
Bury Drlg Co	1	rotary, dsl	.....	265	3,000
Highland Oil Co	2	cable, dsl	B Erie 24-L	.....	3,000
		Marion County			
Tri-County Expl Co Inc	1	rotary, gaso	.....	25	1,200/2⅞
		Pike County			
Henry Gwaltney Drlg Co	1	rotary, dsl	.....	200	3,000
		Posey County			
Ardee Oil Co	1	rotary, dsl	Emsco GA-160-T	.....	3,500
		Sullivan County			
Central Drlg Co	1	rotary, gas	Wilson Super	210	3,000
		Vanderburgh County			
Big Seven Drlg Co	1	rotary, dsl	Emsco GB-160T	300	4,500
KANSAS					
		Barber County			
Garvey Drlg Co	3	rotary, dsl	Unit U-15	175	5,000
Graham-Messman-Rinehart Drlg Co	1	rotary, dsl	Cardwell D	.....	4,500
	1	cable, dsl	Cardwell RL	.....	.....
	2	cable, dsl	Cardwell RL	.....	.....
K & E Drlg Inc	1	rotary, dsl	Oil Well F-52	285	6,000
		Barton County			
Buick Drlg Co	2	rotary, dsl	Wilson	300	4,500
Garvey Drlg Co	11	rotary, dsl	Wilson Giant	175	5,000
Lewis Drlg Co	1	rotary, dsl	Cardwell S	260	4,500
Shelley-Miller Drlg Inc	1	rotary, dsl	Wilson	.....	5,500
Signal Oilfield Service	9	cable, gas	Cardwell RL	.....	.....
	6	cable, gas	Cardwell RL	.....	.....
	1	cable, gas	Cardwell RL	.....	.....
	3	cable, gas	Cardwell RL	.....	.....
L C Smitherman Drlg Co	6	cable, btne	Cardwell RL	.....	7,500
		Brown County			
L C Smitherman Drlg Co	4	cable, btne	Cardwel RL	.....	4,500/cable
	8	rotary, btne	Cardwell	145	4,000
		Chautauqua County			
Veeder Supply & Dev Co	E	rotary, dsl	Franks 658-TRD	270	3,500
		Clark County			
Unit Drlg Co	2	rotary, gas-btne	Unit U-15	900	8,500
	3	rotary, dsl	Natl 50-A	700	6,500
		Cowley County			
Kriswell Drlg Co	1	rotary, dsl	Unit U-34	200	4,500
		Ellis County			
Garvey Drlg Co	8	rotary, dsl	Wilson Giant	175	5,000
Graham-Messman-Rinehart Drlg Co	3	rotary, dsl	Cardwell S	.....	4,000
Mallonee Drlg Co Inc	1	rotary, btne	Cardwell	220	4,500
The Carl Todd Drlg Co	1	rotary, dsl	.....	350	5,600
Transit Corp	2	rotary, dsl	Emsco	230	4,500
Veeder Suppy & Dev Co	D	rotary, dsl	Natl T-25	280	4,500
		Graham County			
Harms-Burt Drlg Co	1	rotary, dsl	Emsco 250	150	5,000
Powell Drlg Co	1	rotary, dsl	Emsco GB-350	.....	6,500
		Greenwood County			
Ward A McGinnis	1	rotary, dsl	Franks 5000	.....	.....
	2	rotary, gas-btne	Joy 200	.....	.....
	2	cable, gaso btne	Star 83	.....	.....
		Hamilton County			
D & M Drlg Co Inc	1	rotary, gas-btne	Natl 50	550	7,500
Gabbert-Jones Drlg Co	2	rotary, gas	Emsco 350	450	7,000
		Harper County			
Gabbert-Jones Drlg Co	3	rotary, gas	Emsco 300	320	5,000
Garvey Drlg Co	14	rotary, dsl	Wilson Giant	175	5,000
Graham-Messman-Rinehart Drlg Co	2	rotary, dsl	Unit U-15	.....	6,000
Viersen & Cochran	14	rotary, gas	Natl T-25	325	5,500
		Haskell County			
Helmerich & Payne Inc	C-13	cable, dsl	Franks	.....	6,000

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Hodgeman County					
Lewis Drlg Co	4	rotary, dsl	Cdwll J-450	260	6,000
Kingman County					
D & M Drlg Co Inc	2	rotary, gas-btne	Brwstr N-4	225	5,000
	3	rotary, gas-btne	Unit U-10	350	5,000
Rupp-Ferguson Oil Co	1	rotary, dsl	Idoco, H-35	350	5,000
Kiowa County					
Falcon Seaboard Drlg Co	26	rotary, dsl	Both Twister	225	6,500
Labette County					
Veeder Supply & Dev Co	BE-2	cable, dsl	B Erie	.....	3,500
Logan County					
Buick Drlg Inc	1	rotary, dsl	Unit U-34	300	5,000
Meade County					
Lewis Drlg Co	2	rotary, dsl	Unit U-15	260	6,000
Midwestern Drillers Inc	2	rotary, dsl	Unit U-15	465	7,500
	4	rotary, gas	Emsco 500	545	8,000
Nye & Snell Drlg Co	1	rotary, gas	Oilwell 550	375	6,000
The R W Rine Drlg Co	1	rotary, btne-gas	Unit U-15	620	7,500
Morton County					
Garvey Drlg Co	5	rotary, dsl	Unit U-15	175	5,000
	15	rotary, dsl	Wilson Giant	175	5,000
Jet Drlg Co Inc	4	rotary, gas-btne	Brwstr N-4	300	5,000
Midwestern Drillers Inc	5	rotary, dsl	Unit U-15	430	6,500
Musgrove Petroleum Corp	3	rotary, dsl	Natl 50	250	5,000
Pratt County					
Beardmore Drlg Co	1	rotary, dsl	Natl 50	300	6,000
Reno County					
Garvey Drlg Co	9	rotary, dsl	Wilson Giant	175	5,000
Rooks County					
K & E Drlg Inc	2	rotary, dsl	Natl T-20	285	5,000
Rush County					
Gabbert-Jones Drlg Co	1	rotary, gas	Emsco 300	320	5,000
Russell County					
Anschutz Drlg Co Inc	1	rotary, dsl	Wilson Giant	300	5,000
Saline County					
Donald T Ingling	2	rotary, btne	Brwstr CR-300	.....	4,000
Sedgwick County					
Ainsworth Inc	3	rotary, gaso	Joy	100	3,000/2⅞
	4	rotary, gaso	Joy	100	3,000/2⅞
	6	rotary, gaso	Joy	100	3,000/2⅞
Beardmore Drlg Co	2	rotary, dsl	Emsco 300	300	4,000
Seward County					
Musgrove Petroleum Corp	2	rotary,dsl	Emsco 50	300	7,000
Stafford County					
Anschutz Drlg Co Inc	10	rotary, dsl	Brwstr N-55	600	7,500
Garvey Drlg Co	10	rotary,dsl	Wilson Giant	175	5 000
Harms-Burt Drlg Co	2	rotary,dsl	Emsco 350	160	6,500
Reserve Drlg Co Inc	3	rotary,dsl	Natl T-32	220	5,500
Transit Corp	4	rotary,dsl	Emsco	250	4,500
Sumner County					
Ainsworth Inc	2	rotary,gaso	Failing	100	1,500/2⅞
L C Smitherman Drlg Co	1	rotary, dsl	Brwstr N-4	185	5,500
	2	rotary, dsl	Unit U-34	165	4,500
	3	rotary, dsl	Brwstr N-4	265	5,500
	5	cable, btne	B Erie 22-W	.....	1,000/cable
	10	rotary, btne	Cardwell L	135	4,500
Trego County					
Musgrove Petroleum Corp	4	rotary,dsl	Franks 45	200	4,000
Transit Corp	3	rotary,dsl	Emsco	200	4,000
KENTUCKY					
Henderson County					
Delta Drlg Co	12	rotary, dsl	Brwstr N-4	260	5,000
Hopkins County					
D B Lesh Drlg Co	1	rotary, dsl	.....	200	4,000
Riley & Gammon	1	cable, dsl	B Erie 22	.....	.....
	2	cable, gaso	B Erie 20	.....	.....
Union County					
Kendall-Davis Drlg Co Inc	1	rotary, dsl	Wilson Mogul	300	4,000

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
LOUISIANA					
Acadia Parish					
Brewster-Bartle Drlg Co Inc	6	rotary,stm	Natl 81½ F.E.	.....	13,500
Bullard Drlg Co Inc	2	rotary, stm	Emsco ECB	800	16,000
Delta Gulf Drlg Co	15	rotary, stm	Idoco Big Gnt	1200	15,000
Falcon Seaboard Drg Co	2	rotary, stm	Idoco Giant	1200+	25,000
Mac Drlg Co	12	rotary, stm	Natl 23-9-FED	500	15,000
Owen Drlg Co	1	rotary, stm	Idoco Big Giant	540	15,000
	3	rotary, gas	Idoco M-1000	900	12 500
	6	rotary, gas	Unit U-15	555	8,000
Ascension Parish					
Hawkins-Wilkins Prod Co	2	rotary, stm	Emsco UBLS	1000+	14,000
Wheless Drlg Co	5	rotary, stm	Emsco UBLS-54	900+	11,000
Assumption Parish					
Crawford Drlg Co	2	rotary, stm	Emsco ECA	.....	15,000
Gracey-Hellmus Corp	2	rotary, stm	Natl 23-9FEC	1020	15,000
Carl B King Drlg Co of Tex	12	rotary, gas-gaso	Natl 75	1000	12,500
Beauregard Parish					
Pernie Bailey	1	rotary, gas	TIW CT-5	650	9,0000
The Power Rig Drlg Co	2	rtry, gs-gso-btne	Unit U-15	600	9,500
	3	rotary, gas-btne	Idoco 800	1000	12,000
Bienville Parish					
Montgomery Drlg Co	1	rotary, gas-btne	Emsco GA-550	550	9,500
Bossier Parish					
Cardinal Drlg Co Inc	1	rotary, dsl	Idoco H-35D	450	7,000
	2	rotary, dsl	Idoco H30D	450	6,000
Drlg & Expl Co of Del Inc	36	rotary, stm	Natl 34-8	1400	15,000
The H & S Drlg Co	2	rotary, gas-btne	.....	1000	14,000
Caddo Parish					
C M Robenson Drlg Co	1	rotary, gas-btne	Brwstr N-45	400	7,300
Tex-Mex Drlg Co	12	rotary, gas	Unit U-15	.....	9,000
Wheless Drlg Co	2	rotary, gas-btne	Wilson Atlas	600	8,500
Calcasieu Parish					
Bilbo-Redding Drlg Co Inc	Bgo 6	rotary, dsl	Oil Well 76	1050	12,500
	10	rotary, stm	Emsco UBLS-54-10	900	12 500
Delta Gulf Drlg Co	1	rotary, stm	Natl 23-9FE	1200	13,000
Harry L Edwards Drlg Co	5	rotary, stm	Natl 23-10¼FE	1000+	16,000
	8	rotary, stm	Natl 23-9-S	1000+	16 000
Gilger Drlg Co Ltd	1	rotary, gas-btne	Wilson 370	225	6,000
Cameron Parish					
Carnes W Weaver Drlg Co	3	rotary, gas-btne	Oil Well	700	10,500
Brewster-Bartle Drlg Co Inc	Bgo	Lavaca rotary, dsl	Oil Well 96	.....	16,000
Crown Drlg Co of Tex	Bgo 1	rotary, dsl	Both 1013	1524	15,000
Drlg & Expl Co of Del Inc	40	rotary, gas-gaso	Emsco GB-500	700	10 000
Falcon Seaboard Drlg Co	29	rotary, stm	Natl 3410	1200+	25,000
Gilger Drlg Co Ltd	6	rotary, stm	Natl	1000+	15,000
Win Hawkins Drlg Co	3	rotary, stm	Emsco UBLS 54	1000+	14,000
Mac Drlg Co	10	rotary, gas-btne	Wilson Titan	1000	15,000
The Power Rig Drlg Co	4	rotary, gas-btne	Unit U-15	700	10,000
	9	rotary, stm	Idoco Big Gnt	500	15,000
Cameron (Offshore) Parish					
Rowan Drlg Co Inc	17	rotary, dsl	Natl 125	1950	15,000
Salt Dome Production Co	19	rotary, dsl	Both 1013	1700	15,000
Claiborne Parish					
Arrow Drlg Co	16	rotary, gas-elec	Emsco	840	10 000
	25	rotary, gas	Idoco 1000	840	10 000
Big Chief Drlg Co	31	rotary, gas	Emsco 800	1100	12,500
Drlg & Expl Co of Del Inc	33	rotary, stm	Emsco UBLS	1200	13,000
	34	rotary, stm	Natl 24-36	1000	12,000
The H & S Drlg Co	1	rotary, gas-btne	.....	1000	12,000
Jet Drlg Co Inc	6	rotary, gas btne	Brwstr N-95	1400	15,000
Johnson Drlg & Service Co	2	rotary, dsl	Both Twister	225	6,500
Wheless Drlg Co	13	rotary, gas-btne	Emsco J-750	700	10,500
Woolf & Magee Inc	1	rotary, stm	Natl 34	.....	15,000
Concordia Parish					
Dorris Ballew Inc	5	rotary, dsl	Unit U-15	380	7,500
	6	rotary, dsl	Unit U-15	380	7 500
Woolf & Magee Inc	11	rotary, gas-btne	Both S-45	275	4,500/2⅞
DeSoto Parish					
Milton Crow Inc	4	rotary, gas	Brwstr N-7	600	7,500
Mercury Drlg Corp	2	rotary, gas	Wilson Giant	300	5,000

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
East Baton Rouge Parish					
M M Lindsey Drlg Co	2	rotary, gas	Natl T-32	290	6,000
Evangeline Parish					
J B Fletcher Drlg Co	3	rotary, dsl	Wilson Giant	.....	10,000
Franklin Parish					
J B Fletcher Drlg Co	1	rotary, gas-btne	Unit U-15	.....	7,500
	2	rotary, dsl	Wilson Giant	.....	8,500
Lamar Drlg Corp	1	rotary, gas	Unit U-15	420	7,500
Wheless Drlg Co	1	rotary, gas-btne	Emsco G-42	600	7,500
Iberia Parish					
Dorris Ballew Inc	1	rotary, dsl	Wilson Titan	760	12,500
Crown Drlg Co of Texas	6	rotary, gas	Bath MC-450	675	10,500
	7	rotary, gas	Bath MC-450	925	11,500
Harry L Edwards Drlg Co	6	rotary, stm	Oil Well 9-P	1000+	15,000
Falcon Seaboard Drlg Co	4	rotary, stm	Wheeling	1000+	17,000
Grace Drlg Co	2	rotary, gas-btne	Unit U-10	310	8,000
	3	rotary, gas-btne	Unit U-15	408	9,000
C B Webster Drlg Co	3	rotary, gas	Emsco J-1250	900	15,000
Wheless Drlg Co	6	rotary, gas-btne	Wilson Titan	1000	12,000
	Bge 12	rtry, gas-btne	Natl 80	1200	12,000
Iberville Parish					
Crawford Drlg Co	1	rotary, dsl	Brwstr N-7	695	9,000
The Grey Wolf Drlg Co	1	rotary, gas-btne	Emsco GB-800	945	12,500
Kerr-McGee Oil Ind Inc	29	rotary, dsl	Natl 75-900	1060	11,000
M M Lindsey Drlg Co	1	rotary, gas	Houston 876	380	7,500
Jackson Parish					
Pyburn-Langford Drlg Co	1	rotary, dsl	Ideco M-750	500	9,000
Jefferson Parish					
Delta Gulf Drlg Co	16	rotary, dsl	Bath MC-950	1200	15,000
	24	rotary, dsl	Bath MC-950	900	15,000
Rowan Drlg Co Inc	21	rotary, dsl	Emsco EC-4-54L	1000	12,000
Jefferson (Offshore) Parish					
Llano Drlg Co	6	rotary, dsl	Oil Well 96	2475	18,000
Jeffersen Davis Parish					
Brewster-Bartle Drlg Co Inc	1	rotary, stm	Ideco Big Gut	.....	15,000
Drlg & Expl Co of Del Inc	32	rotary, stm	Emsco ECA	1400	15,000
Harry L Edwards Drlg Co	7	rotary, stm	BIW 12	1000+	15,000
Gilger Drlg Co Ltd	4	rotary, stm	Emsco	1000+	12 000
Hawkins-Wilkins Prod Co	1	rotary, stm	Natl 34-10-FE	1000+	16,000
Win Hawkins Drlg Co	2	rotary, gas-btne	Unit U-15	.....	7,500
The Power Rig Drlg Co	8	rotary, gas-btne	Ideco 7-11	1500	15,000
C B Webster Drlg Co	7	rotary, stm	Emsco ECA-10½	1600	15,000
	8	rotary, stm	Natl FE-3410	1600	15,000
Wheless Drlg Co	10	rotary, gas-btne	Brwstr N-7	900	9,500
Lafayette Parish					
Delta Drlg Co	20	rotary, gas-btne	Emsco J-1250	1520	15,000
Falcon Seaboard Drlg Co	1	rotary, stm	ECA-10	1200+	25,000
	11	rotary, stm	BIW-12	1000+	17,000
	30	rotary, stm	Natl 3410	1200+	25,000
Owen Drlg Co	4	rotary, stm	Emsco UBLS-54	1000+	14,000
LaFourche Parish					
Brewster-Bartle Drlg Co Inc	Bge	East Bay rotary, dsl	Oil Well 96	.....	16,000
Delta Drlg Co	14	rotary, stm	Ideco Big Gut	900	15,000
	11	rotary, stm	Emsco UBLS-54-10	1000	15,000
Gilger Drlg Co Ltd	5	rotary, stm	Emsco	1000+	14,000
Win Hawkins Drlg Co	4	rotary, stm	Natl 34-10-FE	1000+	16,000
Mac Drlg Co	3	rotary, stm	Natl 23-9-S	1000+	15,000
Owen Drlg Co	7	rotary, stm	Emsco	1000+	16,000
Rowan Drlg Co Inc	1	rotary, dsl	Emsco ECA-4-54L	1600	18,000
	3	rotary, dsl	Emsco EDA-60L	1150	18,000
	6	rotary, dsl	Emsco ED	1200	18,000
	13	rotary, dsl	Emsco FCA-4-54L	1700	18,000
Standard-Fryer Drlg Co	1	rotary, gas-btne	Oil Well 76	1150	12 000
Wheless Drlg Co	Bge 9	rotary, dsl	Natl 130	1300	16,000
	Bge 11	rtry, gas-btne	Emsco J-1250	1200	13,500
Plaquemines Parish					
Bateman Drlg Co	5	rotary, dsl-elec	.....	900	15 000
	6	rotary, dsl-elec	.....	900	16,000
Brewster-Bartle Drlg Co Inc	Bge	Laguna Madre rotary, dsl	Oil Well 96	.....	16,000
Delta Gulf Drlg Co	22	rotary, gas-btne	Emsco J-1100	1200	15,000
Golden Meadow Well Service	5	rotary, dsl	Bath 450	725	10,000
	6	rotary, dsl	Bath 1013	1450	15,000
Gracey-Hellums Corp	1	rotary, stm	Natl 34-10FE	805	15,000
Prince Drlg Co	Bge 6	rotary, dsl	Oil Well 96	1500	15 000
	Bge 2	rotary, dsl	Oil Well 96	1850	16 000
Salt Dome Prod Co	Bge 3	rotary, dsl	Natl 110	750	12,500
Rowan Drlg Co Inc	14	rotary, dsl	Emsco ECA-4-54L	1600	18,000
	18	rotary, stm	Emsco ED	1800	18,000
Plaquemines (offshore) Parish					
Win Hawkins Drlg Co	5	rotary, dsl	Ideco PR-1050	900	14,000
Kerr-McGee Oil Ind Inc	39	rotary, dsl	Natl 125	1880	16,000
	40	rotary, dsl	Emsco J1600	1250	16,000
Richland Parish					
M J Delaney Co	28	rotary, gas-btne	Oil Well 96	500	14,000
Montgomery Drlg Co	3	rotary, gas-btne	Cardwell S	225	5,000
Sabine Parish					
Woolf & Magee Inc	5	rotary, gas btne	Bath MC-450	800	11,000
St. Charles Parish					
Harry L Edwards Drlg Co	Bge 10	rotary dsl	Ideo PR-1050	1000	16 000
Rowan Drlg Co Inc	8	rotary, gas	Natl 125	1260	15,000
St. James Parish					
Wheless Drlg Co	7	rotary, stm	Natl 34-10FE	1000+	15,000
St. Landry Parish					
Brewster-Bartle Drlg Co Inc	10	rotary, gas	Oil Well 76	.....	11,000
Rowan Drlg Co Inc	20	rotary, gas	Natl 75	900	9,000
The Power Rig Co	Bge 7	rotary, dsl	Emsco GB-800	1200	15,000
St. Martin Parish					
Bullard Drlg Co Inc	1	rotary, stm	Natl 34-10FE	800	16 000
Delta Gulf Drlg Co	5	rotary, gas btne	Natl 100	900	12,000
	11	rotary, gas-btne	Natl 75	800	9 500
	12	rotary, gas-btne	Emsco J-1000	1020	13,000
	19	rotary, stm	Ideal 34-10-FE	1200	15,000
Harry L Edwards Drlg Co	4	rotary, stm	BIW 12	1000	15.000
Falcon Seaboard Drlg Co	12	rotary, stm	BIW-12	1200+	25,000
The Power Rig Drlg Co	Bge 6	rotary, gas-btne	Emsco GB-500	800	11,000
C B Webster Drlg Co	4	rotary, stm	Ideal FE-34	1200	15,000
St. Mary Parish					
Ashby Drlg Co Ltd	2	rotary, dsl	Natl T-20	300	8 000
C G Glasscock Drlg Co	Bge 3	rotary, dsl	Emsco J-1250	1500	17 000
The Grey Wolf Drlg Co	3	rotary, stm	BIW 12	1050	13.500
B L McFarland Drlg Corp	Bge 1	rotary, dsl	Brwstr N-75	700	10 000
C B Webster Drlg Co	5	rotary, stm	Natl FE-23	1350	15,000
	6	rotary, stm	Emsco ECA-10½	1100	15,000
Wheless Drlg Co	8	rotary, stm	Emsco UBLS-54	1000+	15 000
	Bge 14	rotary, dsl	Emsco J-1400	1300	16,000
St. Mary (Offshore) Parish					
Salt Dome Prod Co	12	rotary, dsl	Beth Tornado	1350	14,000
Tensas Parish					
Arrow Drlg Co	14	rotary, gas	Wilson	600	8,000
Dorris Ballew Inc	2	rotary, dsl	Wilson Titan	760	12 500
Zach Brooks Drlg Co	7	rotary, gas-dsl	Brwstr N-75	1100	11 000
C A Hilburn Drlg Contr	2	rotary, gas	Wilson	550	10.000
	4	rotary, gas	Wilson	550	10,000
Woolf & Magee Inc	7	rotary, gas	Bath-MC-450	800	11,000
Terrebonne Parish					
Brewster-Bartle Drlg Co Inc	Bge	Capano rotary, dsl	Oil Well 96	.....	16,000
	Bge	Vermillion Bay rotary, dsl	Oil Well 96	.....	16,000
	Bge	West Bay rotary, dsl	Oil Well 96	.....	16 000
C G Glasscock Drlg Co	Bge 4	rotary dsl	Natl 125	1200	16,000
Gracey-Hellums Corp	3	rotary, dsl	Unit U-20	1775	20,000
Wheless Drlg Co	4	rotary, stm	Emsco UBLS-54	1000+	12,000
Terrebonne (Offshore) Parish					
Big Chief Drlg Co	34	rotary, dsl-elec	Emsco EDA	1650	.....
Kerr-McGee Oil Ind Inc	44	rotary, dsl	Ideco 1350	1760	20,000



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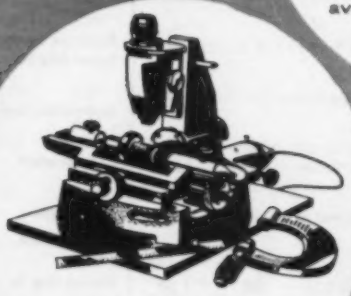

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Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Vermilion Parish					
Columbia Drlg Co	Bge 1	rotary, gas-gaso	TIW CT-5	300	7,500
Falcon Seaboard Drlg Co	3	rotary, stm	BIW-12	1000+	17,000
Wm Hawkins Drlg Co	1	rotary, stm	BIW-14	1000+	16,000
Carl B King Drlg Co of Tex	15	rotary, gas-gaso	Unit U-30	1500	13,500
Mac Drlg Co	11	rotary, stm	Natl 23-9-S	600	15,000
Standard-Fryer Drlg Co	9	rotary, dsl	Oil Well 96	1350	15,000
Vermilion (Offshore) Parish					
Kerr-McGee Oil Ind Inc	45	rotary, dsl	Oil Well 96	1100	16,000
Webster Parish					
Johnson Drlg & Service Co	1	rotary, dsl	Bath Breeze	200	4,500
MARYLAND					
Garrett County					
Delta Drlg Co	10	rotary, dsl	Unit U-15	560	7,000
MICHIGAN					
Arenac County					
Gordon Drlg Co	12	rotary, dsl	Wilson Giant	.....	7,000
	5	cable, btne-gas	Cardwell	.....	.....
Clare County					
Gordon Drlg Co	10	rotary, btne-gas	Oil Well 66	.....	10,000
Gladwin County					
Gordon Drlg Co	8	rotary, btne-gas	Natl 50-A	.....	10,000
Mason County					
Gordon Drlg Co	7	rotary, btne-gas	Oil Well 64	.....	6,000
Midland County					
Gordon Drlg Co	11	rotary, dsl	Wilson Giant	.....	10,000
Newaygo County					
Fen-Par Exploration Co Inc	1	rotary, dsl	Failing 1500	100	1,500
Gordon Drlg Co	1	rotary, btne-gas	Oil Well 64	.....	5,000
Osceola County					
Gordon Drlg Co	3	rotary, btne-gas	Oil Well 64	.....	6,000
MISSISSIPPI					
Adams County					
Petersen Drlg Co	4	rotary, dsl	Unit U-15	500	8,500
Woolf and Magee Inc	12	rotary, gas-btne	Bath S-45	275	4,500/2⅞
Jasper County					
McCalman Drlg Co Inc	1	rotary, dsl	Brwstr N-4	.....	5,500
Jefferson County					
Petersen Drlg Co	5	rotary, gas	Cardwell S	320	6,000
Jones County					
Drlg & Explor Co of Del Inc	38	rotary, stm	Emsco H-46M	1000	12 000
	39	rotary, gas-gaso	Emsco J-1100	1200	15,000
	41	rotary, gas-gaso	Emsco J-1100	1500	15,000
Trans-Tex Drlg Co	3	rotary, gas-btne	Natl 110	1400	13,500
Monroe County					
Arrow Drlg Co	10	rotary, gas	Emsco 500	560	8,000
Pearl River County					
Crawford Drlg Co	3	rotary, stm	Oil Well 96	.....	10,500
Smith County					
Arrow Drlg Co	5	rotary, gas	Emsco	1250	14 000
Drlg & Explor Co of Del Inc	37	rotary, gas-gaso	Emsco GB-800	1200	12,000
Stone County					
Dorris Ballew Inc	4	rotary, dsl	Wilson Titan	760	15,000
Wilkinson County					
Petersen Drlg Co	1	rotary, dsl	Cardwell D	500	9,500
Wilson Drlg Co Inc	1	rotary, dsl	Idaco H-35-D	212	7,000
MONTANA					
Carbon County					
Mountain States Drlg Co Inc	9	rotary, gas-dsl	Natl 125	1400	15,000
Carter County					
Mesa Drlg Co Div of Camay	3	rotary, dsl	Natl 50-A	510	7,500
J D Sprecher	2	rotary, dsl	Emsco J-750	600	9,500
Dawson County					
Helmerich & Payne Inc	15	rotary, dsl	Oil Well 76	700	10,000
Fallon County					
Brinkerhoff Drlg Co	21	rotary, dsl	Emsco GC-500	800	10,000
Zach Brooks Drlg Co	4	rotary, gas-dsl	Brwstr N-75	1100	11 000
	6	rotary, gas-dsl	Brwstr N-75	1100	11,000
Hewit-Gulick Drlg Co	1	rotary, dsl	Natl 50-A	970	8,000
	2	rotary, dsl	Natl 80	970	12,000
Glacier County					
Kullberg & Otthouse Inc	1	rotary, dsl	Unit U-15	300	7,500
M-H-O Drlg Co	4	cable, gas btne	B Erie 36L	.....	4,500/cable
	5	cable, gas-btne	B Erie 36L	.....	3 500/cable
	6	cable, dsl	B Erie 36L	.....	3,500/cable
	8	rotary, gas-btne	Unit U-15	800	8,000
Powder River County					
Anschutz Dri Co Inc	3	rotary, dsl	Wilson Giant	300	5,000
McCone County					
Rowan Drlg Co Inc	5	rotary, gas	Natl 75	840	11,000
Roosevelt County					
Zach Brooks Drlg Co	3	rotary, gas-dsl	Brwstr N-7	750	8,500
	5	rotary, gas-dsl	Brwstr N-7	800	8,500
Paul F Rutledge	3	rotary, dsl	Bath M-450	450	12,000
Toole County					
M-H-O Drlg Co	7	cable, dsl	B Erie 48L	.....	6,000
Treasure State Drlg Co	1	cable, gas-gaso-btne	B.Erie 36-L	.....	.....
Treasure County					
Gabe McCall Drlg Co	2	rotary, gas	.....	500	7,500
Valley County					
Mountain States Drlg Co Inc	17	rotary, dsl	Natl T-32	540	6,000
Signal Drlg Co	3	rotary,-dsl	.....	800	9,500
Wheatland County					
Exploration Drlg Co	9	rotary, gas	Bath S-50	255	5,500
Wibaux County					
J. D. Sprecher	4	rotary, dsl	Ideal 80-B	600	10,000
Yellowstone County					
Tom Knight	1	rotary, gaso	Union Tool	250	5,000
NEBRASKA					
Banner County					
Garvey Drlg Co	6	rotary, dsl	Unit U-15	275	8,500
	17	rotary, dsl	Wilson Giant	300	7,500/2½
Cheyenne County					
Lewis Bros Inc	1	rotary, dsl	Cardwell J-450	300	7,200
Deuel County					
Brinkerhoff Drlg Co	24	rotary, btne	Natl T-12	.....	3,000
Kimball County					
Ashby Drlg Co Ltd	1	rotary, dsl	Natl T-20	300	8.000
Garvey Drlg Co	12	rotary, dsl	Wilson Giant	300	7,500/2½
Miracle-Fifer Drlg Co	1	rotary, btne	.....	300	8.500
The R W Rine Drlg Co	4	rotary, dsl	Brwstr N-75	520	8.500
	6	rotary, dsl	Brwstr N-75	520	8,500
The Rogers Oil Co Inc	1	rotary, btne	Unit U-15	500	8.500
Don M Rounds Drlg Co Inc	2	rotary, dsl	Cardwell 0	500	9,000
Morrill County					
Anschutz Drlg Co Inc	6	rotary, dsl	Wilson Giant	300	5,000
NEVADA					
White Pine County					
Jet Drlg Co Inc	2	rotary, dsl	Brwstr N-7	600	8,000
NEW MEXICO					
Eddy County					
Aldridge & Stroud Inc	8	cable, LPG	Wichita 61	.....	.....
Great Western Drlg Co	12	rotary, gas-gaso	.....	.....	16,000
	25	rotary, gas-gaso	.....	.....	15,000
Guadalupe County					
Great Western Drlg Co	37	rotary, gas-gaso	.....	.....	7,500
Lea County					
Alven Drlg & Explor Co	2	rotary, gas	Emsco J-750	740	12,000
Arrow Drlg Co	24	rotary, dsl	Emsco 1000	1200	14.000
Big Chief Drlg Co	2	rotary, gas	Natl 100	1425	15,000
Cactus Drlg Corp of Tex	10	rotary, gas-btne	Bath M-58	450	9 000
Carper Drlg Co Inc	4	rotary, gas-btne	Unit U-15	675	8.000
	5	rotary, gas-btne	Bath S-55	650	6 000
Delta Gulf Drlg Co	23	rotary, gas-btne	Wilson Spr Ttn	900	15,000
D-K Drlg Co	2	rotary, gas	Natl 50	450	6,500
Donnell Drlg Co	CT2	cable, gas-btne	Model 61	.....	5,000/cable
Frisbie & Yancey Drlg Co	3	rotary, gas	Wilson Titan	1000	12,500
Great Western Drlg Co	40	rotary, dsl	.....	.....	8,500

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Helmerich & Payne Inc	41	rotary, gas	Natl 110	1200	13,000
	44	rotary, gas	Oil Well 96	1200	15 000
LaMance Drlg Co	1	rotary, btne	Franks 5000	350	5,000
	3	rotary, btne	Oil Well 64	550	6,500
Pete Lomax Drlg Co Inc	1	rotary, gas	Natl 50	250	8,000
Low Drlg Co	4	rotary, gas	Natl 125	1000	12,500
	7	rotary, gas	Wilson	750	10,000
	9	rotary, gas	Natl 125	2000	17,000
	10	rotary, gas	Wilson	1000	12,500
B L McFarland Inc	8	rotary, gas	Brwstr N-75	700	10,000
Makin Drlg Co	1	rotary, gas-gaso	Wilson Titan	975	13.000
	2	rotary, gas-gaso	Wilson Giant	650	8,000
	4	rotary, gas-gaso	Wilson Titan	975	13,000
	6	rotary, gas-gaso	Wilson Giant	650	6,700
	9	rotary, gas-gaso	Wilson Giant	450	5,000
	10	rotary, gas-gaso	Wilson Giant	650	8,000
Midland Drlg Co	1	rotary, gas-btne	Unit U-15	600	8,000
Milhoan Drlg Co	3	rotary, gas	Beth 450	900	10,000
Rowan Drlg Co Inc	9	rotary, gas	Natl 75	900	11,000
Sabine Drlg Co	2	rotary, gas	Ideco PR-1000	1100	18 000
Sharp Drlg Co	34	rotary, gas	Beth 1013	1050	16,000
A W Thompson Inc	3	rotary, gas	Emsco 800	650	11,000
	4	rotary, gas	Beth 810	650	12,500
	6	rotary, gas	Beth 450	600	11,000
	7	rotary, gas	Beth 450	650	11,000
	9	rotary, gas	Clark M-1000	650	12,500
Velma Petroleum Corp	4	rotary, gas	Emsco GA 500	675	9,000
	5	rotary, gas	Emsco GA 500	555	9,000
	7	rotary, gas	Emsco G-300	330	6,000
Rio Arriba County					
Fleeger-Riley Drlg Co Inc	5	rotary, gas	Franks 5000	185	5,000
Roosevelt County					
Exploration Drlg Co	7	rotary, gas	Natl 80B	970	13,000
Sandoval County					
Exploration Drlg Co	10	rotary, gas	Unit U-15	505	8,000
San Juan County					
Fleeger-Riley Drlg Co Inc	6	rotary, gas	Unit U-15	450	8,000
Great Western Drlg Co	19	rotary, dsl	.....	.....	5,500
	20	rotary, dsl	.....	.....	5,500
	30	rotary, gas-gaso	.....	.....	7,500
	31	rotary, gas-gaso	.....	.....	7,500
	36	rotary, gas-gaso	.....	.....	7,500
	41	rotary, gas-gaso	.....	.....	7,500
George W Riley Inc	4	rotary, gas-gaso	Cardwell O	750	10,000
	21	rotary, gas-gaso	Cardwell Tririg	300	5,500
NORTH CAROLINA					
Onslow County					
Burton Drlg Co	7	rotary, gas-gaso	.....	.....	2,500
NORTH DAKOTA					
Burke County					
Calvert Drlg Inc	22	rotary, gas-btne	Ideco H-35	320	5,500
	23	rotary, dsl	Ideco H-526	350	8,500
McKenzie County					
Brinkerhoff Drlg Co	5	rotary, dsl	Emsco J-750	800	10,000
Helmerich & Payne Inc	29	rotary, gas	Natl 75CA	700	10,000
	33	rotary, gas	Oil Well 76	850	10,000
Rowan Drlg Co, Inc	23	rotary, gas	Natl 75	1140	11,000
Mountrail County					
Gabe McCall Drlg Co	3	rotary, gas	.....	840	9,000
Williams County					
Brinkerhoff Drlg Co	17	rotary, gas-btne	Emsco GB-800	900	11 000
Helmerich & Payne Inc	8	rotary, gas	Natl 55	600	7,500
Rowan Drlg Co Inc	15	rotary, gas	Natl 75	1140	11,000
Paul F Rutledge	1	rotary, gas	Beth M-450	450	12,000
OHIO					
Knox County					
Don Slape Drlg Co	5	rotary, dsl	Natl 50	520	7,500
OKLAHOMA					
Alfalfa County					
Graham-Messman-Rinehart	4	rotary, dsl	Unit U-15	.....	6,000
Atoka County					
Viersen & Cochran	10	rotary, gas	Natl 50	325	8,800
Beaver County					
Arrow Drlg Co	9	rotary, gas	Emsco 500	560	8,000
	11	rotary, dsl	Emsco 500	595	8,000
	20	rotary, dsl	Emsco 350	460	7,000

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Big Chief Drlg Co	27	rotary, gas	JS&G Spad Spr	960	9 500
Big X Drlg Co Inc	1	rotary, gas-gaso	.....	750	9,000
Falcon Seaboard Drlg Co	20	rotary, gas-btne	Unit U-15	320	8,500
General Drlg Co	1	rotary	Unit U-15	500	9,000
Helmerich & Payne Inc	26	rotary, gas	Emsco GB-500	500	7,500
	36	rotary, gas	Emsco GB-500-B2	500	7,500
Kerr-McGee Oil Ind Inc	14	rotary, gas	Wilson Giant	575	8,000
Midwestern Drillers Inc	3	rotary, dsl	Unit U-15	650	7,500
The R W Rine Drlg Co	3	rotary, btne-gas	Unit U-15	520	7,500
	5	rotary, btne-gas	Brwstr N-55	520	7 500
Schafer Drlg Co	3	rotary, gas-gaso	Unit U-15	400	10,000
Service Drlg Co	3	rotary, LPG	Unit U-15	650	8 500
Urice Drlg Co	2	rotary, gas-gaso	Emsco GA-500	350	8,000
Webster Drlg Co	2	rotary, gas	.....	600	8,000
Beckham County					
Reading & Bates Inc	2	rotary, gas-btne	Natl 110	1100	13,500
Bryan County					
Kidd Williams Drlg Corp	15	rotary, gas	Wilson Giant	650	10,000
Caddo County					
Falcon Seaboard Drlg Co	33	rotary, gas	Beth 1013	1050	16,000
G H Ray Well Service Co	1	rotary, gaso-gas	Wilson	200	4,500
	5	cable, gaso-gas	Cardwell RL	.....	.....
	6	cable, gaso-gas	Cardwell S60	.....	.....
	7	cable, gaso-gas	Wilson	.....	.....
	8	cable, gaso-gas	Cardwell	.....	.....
Kidd Williams Drlg Corp	5	rotary, gas	Wilson Atlas	825	10,000
Canadian County					
N V Duncan Drlg Co	2	rotary, dsl	Oil Well 648	600	9,000
Carter County					
Fain-Porter Drlg Co	3	rotary, gas	Emsco GA 250 T	375	6 000
Flournoy-Haston Drlg Co	1	rotary, gas	Unit U-34	275	4,500
	2	rotary, gas-btne	Unit U-15	300	8 500
	3	rotary, gas	Wilson Atlas	600	10,000
	4	rotary, gas-btne	Natl 100	700	14,000
H&F Drlg Co	1	cable, dsl	Cardwell RL	200	.....
Tom Jack Drlg Co	2	rotary, gas	Cardwell B88	185	5,000
Riceland Corp	3	rotary, gas	Natl T-32	300	5,000
The Rogers Oil Co Inc	2	rotary, btne	Unit U-15	500	8,500
Schafer Drlg Co	4	rotary, gas-gaso	Unit U-34	200	6,000
	9	rotary, gas-gaso	Ideco H-35	300	7 500
Webster Drlg Co	5	rotary, gas	.....	450	7,500
Cimarron County					
Jet Drlg Co Inc	1	rotary, dsl	Emsco GC-500	300	6 500
Wagner & Wyant Drlg Co Inc	1	rotary, dsl	Unit U-15	300	8,000
Cleveland County					
Big Chief Drlg Co	33	rotary, gas	Natl 55	625	11,000
Big X Drlg Co Inc	2	rotary, gas-gaso	.....	750	10,000
Bryant-Hayward Drlg Co	1	rotary, gas	Natl 50	675	8,500
	3	rotary, gas	Unit U-15	700	9 500
CHRC Drlg Co	1	rotary, gas	Unit U-15	300	9,000
N V Duncan Drlg Co	4	rotary, dsl	Natl 50A	600	9 000
Fain-Porter Drlg Co	1	rotary, gas	Wilson Titan	750	11 000
Falcon Seaboard Drlg Co	21	rotary, gas-btne	Unit U-15	320	8 500
Fleeger-Riley Drlg Co Inc	2	rotary, gas	Wilson Giant	320	8,500
Johnson & Flesher Drlg Co	500	rotary, gas	Emsco GA-500	320	9,000
Lynn Drlg Co	2	rotary, gas-btne	Natl 75	425	10,000
	3	rotary, gas-btne	Natl 75	1000	11,500
Nuckolls-Bell Drlg Co	3	rotary, dsl	Ideco H-525	450	9 000
Reading & Bates Inc	1	rotary, gas-btne	Natl 100	800	11,000
	7	rotary, gas-btne	Natl 75	600	8,000
Coal County					
Fain-Porter Drlg Co	4	rotary, gas	Emsco GB 500	575	8 000
Schafer Drlg Co	1	rotary, gas-gaso	Unit U-40	1200	12,000
Craig County					
Bennett Drlg Co	10	cable, LPG	B Erie 60-L	.....	1,800/Cable
Creek County					
Acacia Drlg Co	2	cable, btne	B Erie 36-L	.....	4,000/cable
Bennett Drlg Co	8	cable, LPG	B Erie 28-L	.....	2,750/cable
	9	cable, LPG	Wkr-Neer 34	.....	4,000/cable
Blackstock Bradley & Dietz Inc	2	rotary, gas	Cardwell	325	4 000
Curt Brown Drlg Co	2	rotary, dsl	Franks Comet	320	5,000
4-J Drlg & Well Servicing Co	1	cable, gaso	B Erie 36-L	.....	4,500/cable
	2	cable, gaso	Wkr-Neer	.....	3,500/cable
Gulf Coast Western Oil Co	1	cable, gas	Wkr-Nr C-34	.....	5 000/cable
C H Hartman	1	cable	.....	.....	3,500/cable

...One

BAKER

RETAINER PRODUCTION PACKER

PRODUCT NO. 415-D

SINGLE ZONE

PERMANENT-TYPE WELL COMPLETIONS

The Baker Retainer Production Packer has been used in nearly every production application, old or new, and promises to play an even greater role in future production applications.

Because it can also be used successfully as a squeeze tool, it is used in a variety of supplemental applications (such as testing, acidizing, formation fracturing, squeeze cementing, etc.) that might be required during the completion or work-over phase of a well. That is why the Baker Retainer Production Packer has been frequently referred to as the "universal" packer, because it is truly the *one* packer that can be used *for all* production and many supplemental applications.

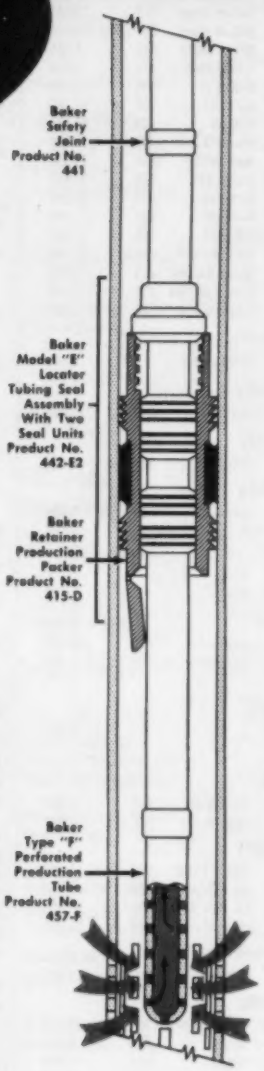
FEATURES

Can be run and set with the speed and accuracy of wire line, as well as on tubing or drill pipe.

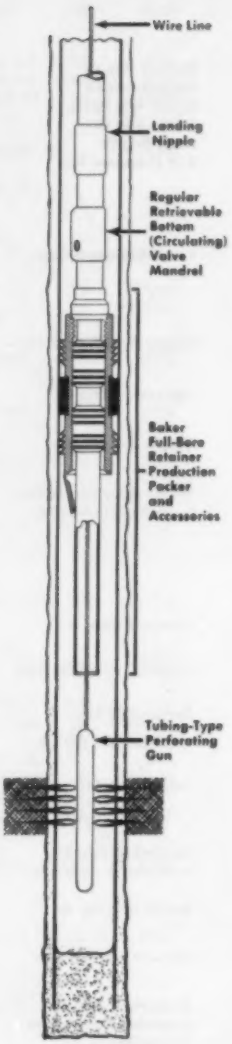
Holds any pressure from either above or below that is safe for the casing, even under temperatures in excess of 300°F.

Pack-off is independent of set-down weight or tension. Tubing string is free; just pick up (or unlatch and pick up) to remove it.

When tubing is removed, flapper valve closes to isolate zone below packer.


Baker Safety Joint Product No. 441
Baker Model "E" Locator Tubing Seal Assembly With Two Seal Units Product No. 442-E2
Baker Retainer Production Packer Product No. 415-D
Baker Type "F" Perforated Production Tube Product No. 457-F

Illustrates Packer set in casing with Locator Tubing Seal Assembly and Production Tube installed for single zone production.


Wire Line
Landing Nipple
Regular Retrievable Bottom (Circulating) Valve Mandrel
Baker Full-Bore Retainer Production Packer and Accessories
Tubing-Type Perforating Gun

Illustrates typical Permanent-Type Well Completion Hook-Up showing perforating operation through and below the Packer.

Baker Locator Tubing Seal Assembly Product No. 442-E2

Baker Retainer Production Packer Product No. 415-D

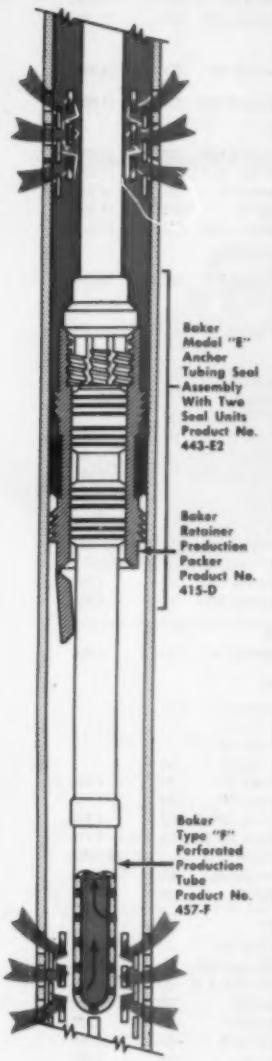
Successfully holds high pressures from above or below

. . . at shallow or record depths
even under temperatures in excess of 300°F.

for all

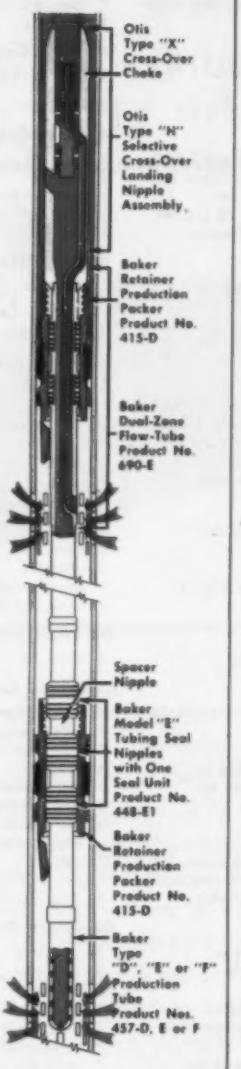
DUAL ZONE

SINGLE PACKER


Baker Model "E" Anchor Tubing Seal Assembly With Two Seal Units Product No. 443-E2
Baker Retainer Production Packer Product No. 415-D
Baker Type "F" Perforated Production Tube Product No. 457-F

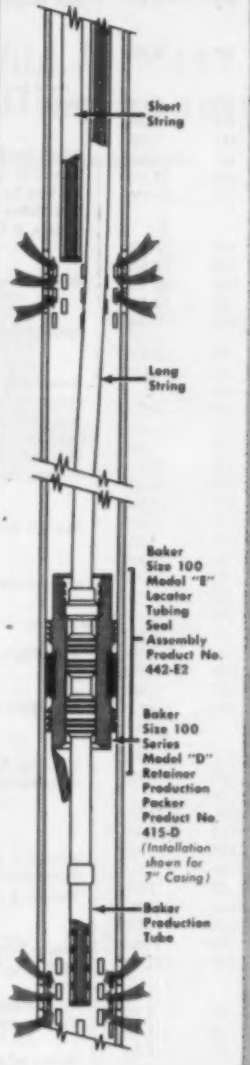
Illustrates Packer set in casing, with anchored production string for dual zone production. Tubing can be released from packer by rotating to right.

SELECTIVE CROSS-OVER


Otis Type "X" Cross-Over Choke
Otis Type "H" Selective Cross-Over Landing Nipple Assembly
Baker Retainer Production Packer Product No. 415-D
Baker Dual-Zone Flow-Tube Product No. 690-E
Spacer Nipple
Baker Model "E" Tubing Seal Nipples with One Seal Unit Product No. 448-E1
Baker Retainer Production Packer Product No. 415-D
Baker Type "D", "E" or "F" Production Tube Product Nos. 457-D, E or F

Illustrates selective two packer dual zone production hook-up (Baker-Otis) with Cross-over Choke installed. Flow pattern can be switched with Parallel Flow Choke.

PARALLEL STRING


Short String
Long String
Baker Size 100 Model "E" Locator Tubing Seal Assembly Product No. 442-E2
Baker Size 100 Series Model "D" Retainer Production Packer Product No. 415-D (Installation shown for 7" Casing)
Baker Production Tube

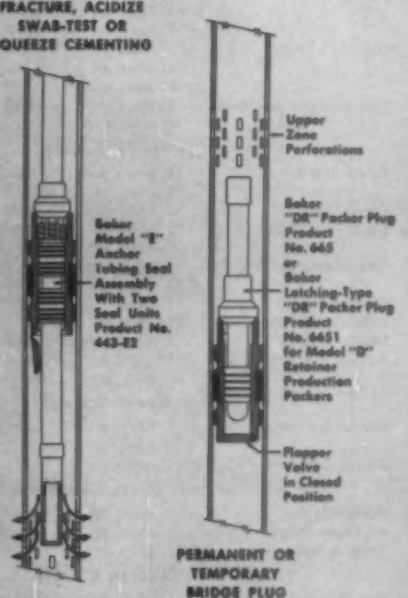
Illustrates simplest type of parallel string installation. Other installations involving two packers with full-opening tubing running through and below lower packer available.

SUPPLEMENTAL APPLICATIONS

WATER OR GAS INJECTION

The Baker Retainer Production Packer contains features that permit it to be used as a squeeze or testing tool as well as a temporary or permanent bridge plug. It is thus used in a variety of supplemental applications such as gas or water injection, testing, fracturing, acidizing, etc., that may be required either during the completion phase of a well or during a later phase.

FRACTURE, ACIDIZE SWAB-TEST OR SQUEEZE CEMENTING


Baker Model "E" Anchor Tubing Seal Assembly With Two Seal Units Product No. 443-E2
Upper Zone Perforations
Baker "DR" Packer Plug Product No. 665 or Baker Latching-Type "DR" Packer Plug Product No. 6651 for Model "D" Retainer Production Packers
Flapper Valve in Closed Position

PERMANENT OR TEMPORARY BRIDGE PLUG

Send for complete information

A new 72 page catalog supplement is now available on the Baker Retainer Production Packer and its many features and applications. Write or ask your Baker Representative for Baker Catalog Supplement No. 502.

BAKER

OIL TOOLS, INC.

HOUSTON • LOS ANGELES • NEW YORK

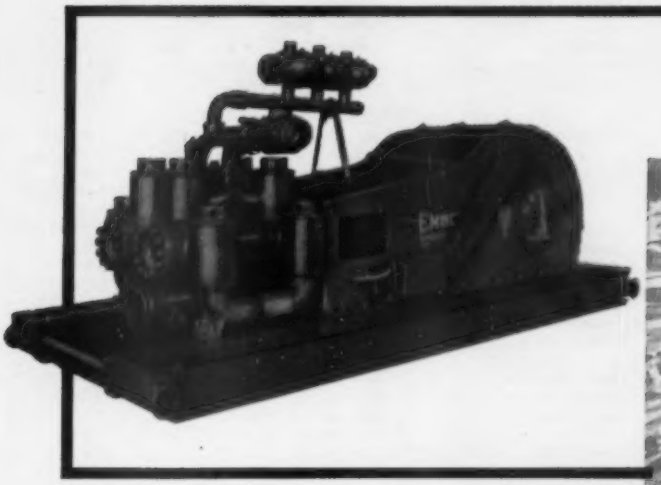
Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Al Johnson Drlg Co	1	rotary, btne	Mayhew	325	3,500
M L (Mike) Marrs Drlg Co	1	cable, gas-prop	B Erie 36-L	.....	.....
	2	cable, gas-prop	B Erie 36-L	.....	.....
	3	cable, gas-prop	B Erie 36-L	.....	.....
	4	cable, gas-prop	B Erie 36-L	.....	.....
Pete Morris Drlg Co	1	rotary, dsl-gas	Wilson Giant	250	5,000
Porter Drlg Co	1	cable, gas-LPG	Wlkr-Nr S-32	.....	3,500/cable
Scat Dig Co	1	rotary, dsl	Emsco 300	300	5,500
	2	rotary, dsl	Wichtex R4	300	5,500
Wade Drlg Co	1	rotary, dsl	Wilson Mogul	145	3,500
	2	rotary, dsl	Jimco	125	1,000/3½
	3	rotary, dsl	Cardwell L	325	4,500
Dewey County					
Viersen & Cochran	7	rotary, gas	Wilson Titan	970	13,500
Garfield County					
Delaney Drlg Co	1	rotary, gas-btne	Unit U-15	450	7,500
DM&R Drlg Inc	1	rotary, gas	Wilson Giant	320	5,000
Hayward Drlg Co	1	rotary, dsl-gas	Wilson	165	2,500
	2	cable, gas	Brwstr	165	4,000/cable
Webster Drlg Co	6	rotary, gas	.....	600	7,500
Wilcox Drlg Co	1	rotary, gaso	Failing 1500	50	1,500/2⅝
Garvin County					
An-Son Drlg Co	1	rotary, gas	Beth MC 450	680	10,000
	2	rotary, gas	Unit U-15	480	7,500
Big Chief Drlg Co	29	rotary, gas	Emsco 1250	1325	15,000
Doak Drlg Co	1	rotary, btne-gas	Natl T-32	300	5,500
T T Eason & Co Div of Eason Oil Co	12	rotary, gas-btne	Emsco J-750	1060	15,000
Falcon Seaboard Drlg Co	8	rotary, gas-btne	Beth 450	450	10,000
General Drlg Co	2	rotary	Natl 50	400	8,000
H&F Drlg Co	2	cable, prop-gas	Cardwell RL	145	.....
Helmerich & Payne	24	rotary, gas	Natl 80	850	10,000
	38	rotary, gas	Natl 80	850	10 000
Tom Jack Drlg Co	1	rotary, gas-dsl	Cardwell MS	185	4,000
Jennings Drlg Co	5	rotary, btne-gas	Wisn Grnt Rdr	450	9,000
	6	rotary, btne-gas	Brwstr	350	6,000
Johnson & Flesher Drlg Co	Franks	rotary, gas	Frnks 6300	255	5,500
Kingery Drlg Co Inc	3	rotary,dsl	.....	210	4,500
	10	rotary, btne-gas	.....	300	4,500
Skipper Drlg Co	1	rotary, gas	Natl T-32	300	5 500
Viersen & Cochran	2	rotary, gas	Natl 55	500	10,500
	3	rotary, gas	Natl 75CA	600	10 500
	4	rotary, gas	Natl 75	600	10,500
Webster Drlg Co	3	rotary, gas	.....	650	10,000
	4	rotary, gas	.....	650	8,500
	8	rotary, gas	.....	1050	12,000
Kidd Williams Drlg Corp	6	rotary, gas	Wisn Spr Ttn	925	15,000
	10	rotary, gas	Wisn Spr Ttn	1050	18,000
Grady County					
Arrow Drlg Co	18	rotary, gas	Emsco 1250	1260	14 000
	21	rotary, gas	Emsco 1000	1260	14,000
Atmar Drlg Co	2	cable, gas	Franks	190	.....
Big Chief Drlg Co	30	rotary, gas	Ideco 1650	1300	14 000
	32	rotary, gas	Natl 110	1650	15,000
Falcon Seaboard Drlg Co	24	rotary, gas-btne	Beth 950	1050	16,000
	28	rotary, gas	Beth 650	1200	16,000
General Drlg Co	5	rotary	Natl	300	7,000
Helmerich & Payne Inc	35	rotary, dsl	Natl 110	1100	13,000
Schafer Drlg Co	5	rotary, gas-gaso	Unit U-40	1000	14,000
Viersen & Cochran	9	rotary, gas	Emsco J-1250	980	14 000
	11	rotary, gas	Natl 110	1525	18,500
Grant County					
Viersen & Cochran	1	rotary, gas	Emsco G-300	325	5,800
	6	rotary, gas	Natl T-25	255	5,500
Zephyr Drlg Corp	6	rotary, gas	Natl 50	350	7,000
Hughes County					
EL&M Drlg Co	1	rotary, gas	Wilson Mogul	450	4,500
Art Logan Drlg Co	1	rotary, dsl	Ideco S25	300	5,000
Troup & Suttles Inc	2	rotary, gas-gaso	Wilson	200	5,000
Jackson County					
Dick Wegener Drlg Contr	1	rotary, dsl	Franks SAL	300	5,500
Kay County					
Atmar Drlg Co	2	rotary, gas	Unit U-34	500	.....
W A Barton Drlg Co Inc	1	rotary, gas	Unit U-34	250	4,500
Tennant Drlg Co	1	rotary, btne	Franks 6000	270	6,000
Lincoln County					
Delaney Drlg Co	2	rotary, gas-btne	Unit U-34	225	5,000
Lynn Drlg Co	1	rotary, gas-btne	Natl 50	300	7,000
Viersen & Cochran	13	rotary, gas	Natl T-16	325	5,200

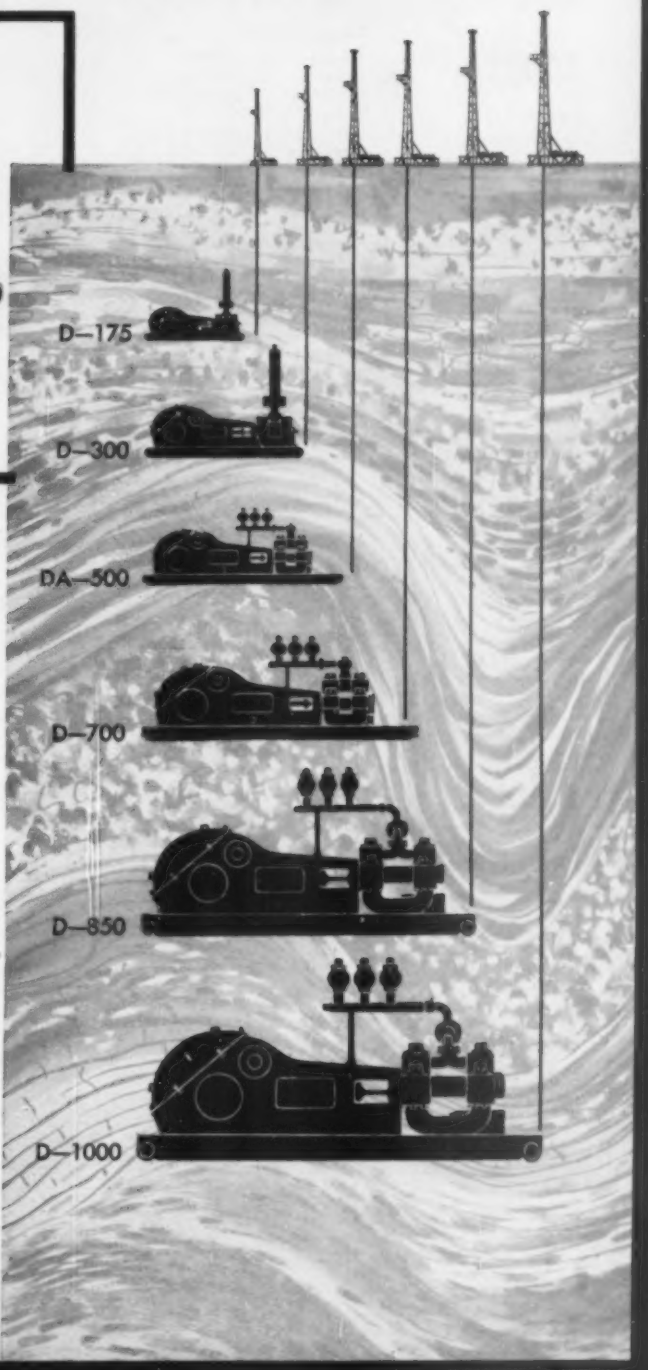
Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Logan County					
An-Son Drlg Co	3	rotary, gas	Beth Breeze	400	4,500
Baker-Munday Drlg Co	1	rotary, gas	Beth Twister	325	7,500
Chambless-Rosen Drlg Co	3	cable, gas	Cardwell	.....	.....
	4	cable, gas	Cardwell	.....	.....
Falcon Seaboard Drlg Co	27	rotary, gas-btne	Unit U-34	185	5,000
Kidd Williams Drlg Corp	11	rotary, gas	Wilson Atlas	775	12,500
Love County					
Riceland Corp	1	rotary, gas	Ideco H-25	250	3,000
	4	rotary, gas	Brwstr N-95	1200	16 000
Dick Wegener Drlg Contr	2	rotary, gas	Unit U-15	500	8 500
	3	rotary, gas	Wheland B-85	950	10,000
Marshall County					
T T Eason & Co Div of Eason Oil Co	14	rotary, gas-btne	Emsco G-500	850	8,000
Gibson & Holliman	5	rotary, dsl	Emsco GB-800	825	11,000
McClain County					
Falcon Seaboard Drlg Co	18	rotary, dsl	Wheland B-85	700	10,000
Helmerich & Payne Inc	40	rotary, gas	Oil Well 96	975	13 000
Jat Drlg Co Inc	5	rotary, gas-btne	Emsco 800	700	10,500
Kerr-McGee Oil Ind Inc	3	rotary, gas	Natl 75	870	11,500
Viersen & Cochran	8	rotary, gas	Emsco J-1000	1200	14,000
Murray County					
Riceland Corp	5	rotary, gas	Brwstr N-75	800	10,000
Muskogee County					
Bennett Drlg Co	3	cable, LPG	B Erie 28-L	.....	2,750/cable
Noble County					
Atmar Drlg Co	1	rotary, dsl	Cardwell	650	.....
Chambless-Rosen Drlg Co	2	cable, gas	Cardwell	.....	.....
Glenn Gillespie & Sons	2	rotary, gas-dsl	Wilson Mogul	380	6,900
Johnson & Flesher Drlg Co	250	rotary, gas	Emsco GA-250	255	5,500
Kirk Drlg Co	1	rotary, LPG	Cardwell	225	4,000
O F Warren Corp	1	rotary, dsl	Emsco GA-250T	274	5,500
Nowata County					
Bennett Drlg Co	4	cable, LPG	B Erie 24	.....	1,500/cable
	6	cable, LPG	B Erie 24-L	.....	1,500/cable
	7	cable, LPG	Wlkr-Noer 32	.....	1,500/cable
The Overby Drlg Co	1	rotary, btne-dsl	Mayhew 1000	180	1,000
	2	rotary, btne, dsl	Mayhew 2000	250	2,500
Okfuskee County					
Folk Drlg Co	1	rotary, dsl	Cardwell RL	200	4,000
Oklahoma County					
Duke Anderson Drlg Co	4	cable, btne-gas	Cardwell R	.....	.....
	1	cable, btne-gas	B Erie 36L	.....	.....
	1	cable, btne	Franks 65	.....	.....
Big Chief Drlg Co	24	rotary, gas	Unit U-45	360	.....
Garr-Woolley Co	1	rotary, gas-btne	Emsco 300	185	5,500
	2	rotary, gas-btne	Emsco 350	255	7,000
	3	rotary, gas-btne	Emsco 500-GB	320	9,500
	4	rotary, gas-btne	Emsco 500-GC	320	9,500
Helmerich & Payne Inc	C12	cable, dsl	Franks	.....	6,000/cable
Nuckolls-Bell Drlg Co	2	rotary, dsl	Ideco H-40	300	7 500
Viersen & Cochran	5	rotary, gas	Natl 50	500	9,000
Okmulgee County					
Acacia Drlg Co	3	cable, btne	B Erie 36-L	.....	4,000/cable
B&W Drlg Co	1	cable, gas	Wlkr-Noer S43	.....	3,500/cable
	2	cable, gas	Wlkr-Noer S-43	140	3,000/cable
Mosker Drlg Co	2	rotary, gas	Joy 300	200	2,500
Slats Honeymoon Drlg Co	1	rotary, gas-btne	Natl 50-A	450	9,000
	2	rotary, gas-btne	Natl 80-A	450	12,000
Trusco Drlg Co Inc	1	rotary, dsl	Franks	190	3,500
Osage County					
Bennett Drlg Co	5	cable, LPG	B Erie 28-L	.....	2,750/cable
Curt Brown Drlg Co	1	rotary, dsl	Franks Comet	320	5,000
Doak Drlg Co	2	rotary, btne-gas	Natl T-20	233	4,000
	3	rotary, btne-gas	Natl T-20	233	4,000
E&M Drlg Co	3	rotary, gas	Cardwell	60	2,000
	2	cable, gas	Wlkr-Noer	.....	.....
Falcon Seaboard Drlg Co	19	rotary, gas-btne	Unit U-34	185	5,000
Glenn Gillespie & Sons	5	rotary, gas	Brwstr N35	190	3,500
	6	rotary, gas	Unit U-34	190	4,500
	7	rotary, gas-dsl	Frnks 658TRD	190	4,000
W C Holt Drlg Co Inc	1	cable, gas	.....	.....	3,000/cable
Indian Drlg Co	1	rotary, btne	Ideco H-25	220	4,000
	2	rotary, dsl	Ideco H-35-S	220	5,000
Al Johnson Drlg Co	2	rotary, btne	Mayhew	325	3,500

Dependable Performance • Advanced Design • Low Cost Operation

EMSCO SLUSH PUMPS

are available in sizes to meet every drilling requirement!





For jet bit, big hole or deep drilling, or for shallow or medium wells, you'll find an EMSCO Slush Pump available to meet your needs. Due to Fabriform construction of the power end, frame is rigid and lightweight, offering easier handling at the rig and less costly transportation. Lubrication is completely automatic. Exclusive patented "exposed" liners enable you to detect and correct liner packing leakage immediately before damage is done. Call your EMSCO representative for bulletins and complete information.

EMSCO

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SP—804

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Mesker Drlg Co	1	rotary, gas	Joy 300	200	2,500
	4	rotary, gas	Joy 300	200	2,500
The Novak Drlg Co	1	rotary, gas	Brwstr N-4	225	3,500
	2	rotary, gas	Unit U-10	300	6 500
	3	rotary, gas	Brwstr N-45	265	5,000
Service Drlg Co	2	rotary, LPG	Unit U-34	300	4,500
	6	rotary, dsl	Brwstr N-4	320	4,500
	9	rotary, dsl	Natl	320	4,000
	10	rotary, LPG	Unit U-34	250	4,000
Signal Oilfield Service	8	cable, gas	Wlkr-Neer C34	.....	.....
	7	cable, gas	Wlkr-Neer C34	.....	.....
L C Smitherman Drlg Co	7	cable, btne	B Erie 36-L	.....	4,500/cable
Target Drlg Corp	1	rotary, gas-btne	Unit U-34	180	5,000
Tolson Drlg Co	1	cable, dsl	Wlkr-Neer S-33	145	4,000/cable
Pawnee County					
Glenn Gillespie & Sons	1	rotary, gas	Unit U-34	380	4,500
	3	rotary, dsl	Wilson Mogul	425	6 000
Pete Morris Drlg Co	2	rotary, dsl-gas	Unit U-34	250	5,000
Unit Drlg Co	1	rotary, gas-btne	Unit U-34	290	5,500
Payne County					
Mustang Drlg Co	1	cable, gas	Wlkr-Neer	.....	.....
Patco Drlg Contr	1	rotary, dsl	Unit U-34	300	4,500
	2	rotary, dsl	Unit U-15	300	7,500
Sabre Drlg Co	2	rotary, dsl	Unit U-34	.....	4,500
	3	rotary, dsl	Unit U-10	.....	6,000
	4	rotary, gas	Brwstr N-3	.....	4,000
Vierson & Cochran	12	rotary, gas	Natl T-25	325	5,500
Pottawatomie County					
Bodard Drlg Co	1	rotary, gas	Unit	225	4,500
	2	cable, gas	Cardwell R	225	7,000/cable
Melco Drlg Co	1	rotary, btne	Brwstr N-35	250	5,000
	2	rotary, btne	Brwstr N-35	250	5,000
Seminole County					
Johnson-Bates Drlg Co	1	rotary, gas	Unit U-34	245	4,500
	2	rotary, gas	Unit U-34	300	5,000
Troup & Suttles Inc	1	cable, gas-gaso	Wlkr-Neer 33	145	9,000/cable
Stephens County					
Big Chief Drlg Co	1	rotary, gas	JS&G Spad Spr	360	6,500
Blackstock Bradley & Dietz	3	rotary, dsl	Cardwell	290	4,000
Bryant-Hayward Drlg Co	2	rotary, gas	Natl 50	675	8 500
Crowe Drlg Co	1	rotary, gas	Wilson Spr 38	175	4,000
R A Davenport Drlg Contr	1	rotary, gas-btne	Natl T-12	225	3,500
T T Eason & Co Div of Eason Oil Co	15	rotary, gas-btne	Emsco T-250	560	6,000
Gibson & Halliman	2	rotary, gas	Unit U-15	350	7,500
Kerr-McGee Oil Ind Inc	41	rotary-gas	Natl 75	1000	11,000
Mardale Drlg Co	1	rotary, gas-gaso	Wichitex R-3	185	2,800
Schafer Drlg Co	8	rotary, gas-gaso	Unit U-34	350	6,000
Texas County					
Garvey Drlg Co	1	rotary, dsl	Unit U-15	500	8,500
Helmerich & Payne Inc	7	rotary,gas	Emsco GB-500-82	500	7,500
Reading & Bates Inc	6	rotary, gas-btne	Natl 50-A	450	7,000
Tillman County					
Falcon Seaboard Drlg Co	23	rotary, gas-btne	Bath Twister	300	6,500
Jennings Drlg Co	4	rotary, btne-gas	Unit U-15	480	8,000
Zephyr Drlg Corp	5	rotary, gas	Natl 50	350	7,000
Tulsa County					
Acacia Drlg Co	1	cable, btne	B Erie 36L	.....	4,000/cable
J M C Drlg Interests	1	cable, gas	Ft Worth	.....	6,500/cable
	2	cabe, gas	Keystone	.....	1,500/cable
Mesker Drlg Co	3	rotary, gas	Joy 300	200	2,500
Riceland Corp	2	rotary, gaso	Failing 1500	35	1,600/2⅞
Wagoner County					
Tyco Drlg Corp	1	cable, gas	.....	138	.....
Washington County					
H&S Drlg Co	1	cable, gas	.....	90	3,000/cable
	2	cable, gas	.....	60	2,000/cable
	3	cable, gas	B Erie 36L	140	4,000/cable
K&S Drlg Co	2	cable, gas	B Erie 28L	.....	.....
Woods County					
Chambless-Rosen Drlg Co	1	rotary, gas	Cardwell	225	5,000
Woodward County					
Baker & Taylor Drlg Co	5	rotary, gas-btne	Natl 110	1800	15,000

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
PENNSYLVANIA					
Berks County					
C S Garber & Sons Inc	1	rotary, dsl	.....	.....	1,200
	2	rotary, dsl	.....	.....	300
	3	cable, gaso	.....	.....	1,500/cable
Clearfield County					
Delta Gulf Drlg Co	20	rotary, gas-btne	Unit U-15	800	8,000
Clinton County					
Delta Drlg Co	24	rotary, dsl	Emsco GC-500	670	8,500
SOUTH DAKOTA					
Harding County					
Kerr-McGee Oil Ind Inc	4	rotary, gas	Natl 75	725	11,000
Pennington County					
Signal Drlg Co	5	rotary, gas	.....	300	4,500
TEXAS					
Anderson County					
Ace Drlg Co	1	rotary, gas	Emsco G-500	680	7,500
Talbert & Hughey Drlg Co	1	rotary, dsl	Bath Breeze	300	6,500/3½
Trant Drlg Co	2	rotary, dsl	Ideco	.....	12,000
Andrews County					
Arrow Drlg Co	22	rotary, dsl	Emsco 1000	1200	14,000
	23	rotary, gas	Wilson	840	10,000
Cactus Drlg Corp of Texas	11	rotary, gas-btne	Brwstr N-55	308	7,000
	7	rotary, gas-btne	Oil Well 96	675	15,000
	3	rotary, gas-btne	Unit U-15	300	8 500
D-K Drlg Co	1	rotary, gas	Natl 50	450	6,500
Davidson Drlg Co Inc	C	rotary, btne	Emsco GC-500	660	8,500
M J Delaney Co	27	rotary, gas-btne	Bath 450	500	11,000
	30	rotary, gas-btne	Bath 1013	500	15,000
The Denver Co	1	rotary, gas	Natly T-20	335	5,500
Donnell Drlg Co	9	rotary, gas-btne	Bath MC-950	1400	13,000
Empire Drlg Co	3	rotary, gas	Brwstr N-75	500	11,000
	5	rotary, gas	Unit U-15	600	8,000
Lloyd French Co	3	rotary, gas-btne	Natl 50	650	7,500
Frisbie & Yancey Drlg Co	5	rotary, gas	Wilson Titan	1000	12,500
Fryer & Hanson Drlg Co	6	rotary, gas-btne	Wison Tiata	1150	12,000
	8	rotary, gas-btne	Oil Well 66	770	9,000
Great Western Drlg Co	27	rotary, gas-gaso	.....	.....	15,000
	34	rotary, dsl	.....	.....	10,000
Hamman Oil & Ref Co	5	rotary, dsl	Brwstr N-4	340	6,000
Helmerich & Payne Inc	43	rotary, gas	Oil Well 76	1000	10,000
Henson Drlg Co	6	rotary, dsl	Unit U-24	250	2,000
Hissom Drlg Co	1	rotary, gas	Emsco 500	600	8 500
Carl B King Drlg Co of Tex	5	rotary, gas-gaso	Natl 100	1000	13 500
La Mance Drlg Co	2	rotary, btne	Unit U-15	550	7,500
Lee Drlg Co	5	rotary, gas-gaso	Natl 100	.....	.....
	6	rotary, gas-gaso	Oil Well 76	1050	13,000
Liano Drlg Co	4	rotary, gas	Natl 75	800	10,000
Pete Lomax Drlg Co Inc	2	rotary, gas	Bath 450	450	10,000
	3	rotary, gas	Bath 45	450	10,000
Charles E Long Jr Inc	1	rotary, gas	Cardwell R	440	5,000
	2	rotary, dsl	Emsco GA 500	520	10,000
Lowe Drlg Co	5	rotary, gas	Natl 75	750	10 000
	6	rotary, gas	Unit U-15	500	7,500
	8	rotary, gas	Natl 80	1200	12,500
Lumac Drlg Co	1	rotary, dsl	.....	265	4,500
B L McFarland Inc	12	rotary, gas	Brwstr N-55	500	7,500
Robinson Brothers Drlg Co	1	rotary, gas	Brwstr N-75	800	10,000
Rowan Drlg Co Inc	7	rotary, gas	Natl 100	1260	14,000
	28	rotary, gas	Natl 125	1200	15,000
A W Thompson Inc	11	rotary, gas	Bath 450	650	11,000
	12	rotary, gas	Emsco 250	350	5,000
Angelina County					
L C Peters Drlg Contr	3	rotary, btne	Brwstr N-45	360	8,000
Trant Drlg Co	1	rotary, dsl	Unit U-15	.....	9,000
Archer County					
Hamilton-Powell Drlg Co	2	rotary, gas	Wison Giant	325	7,000
McCutchen & Graham	3	rotary, btne	Wilson Spr Gnt	350	8,500
Atascosa County					
Armstrong & Horn Drlg Co	1	rotary, dsl	Brwstr N-4	450	7,000
J E Hillier	2	rotary, dsl	Ideco H40	200	7,000
The Oil Corp	5	rotary, gas-btne	Cardwell Tririg	280	6,500
Schimmel Drlg Co	1	rotary, dsl	.....	450	7,500
Austin County					
Brewster-Bartle Drlg Co Inc	4	rotary, gas	Oil Well 76	.....	11,000

USED EVERYWHERE! BY EVERYONE!
for lost circulation control
• HIGHER STRENGTH SEAL
• LASTS LONGER
• SEALS FASTER
• LOWEST MAINTENANCE COST
• PERMITS MUD WEIGHT BUILD UP WITHOUT FORMATION BREAKDOWN
and friction reduction
• LOWERS DRILL PIPE TORQUE
• DECREASES DRAG ON DRILL PIPE DURING TRIPS
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Available through your local mud and service companies
CHEROKEE LABORATORIES, Inc.
HOME OFFICE AND MANUFACTURING PLANT IN TULSA, OKLAHOMA
BRANCHES: MIDLAND, OKLAHOMA CITY, CORPUS CHRISTI, NEW ORLEANS, LAFAYETTE, LA., CASPER

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Baylor County					
Ayers & Burch	3	rotary, btne	Wichtex	185	3,000
Schulz & Brannan Drlg Co	1	rotary, btne	Wsn Mgl Trcr	400	5,000
Bee County					
Fitzpatrick Drlg Co	3	rotary, gas	Brwstr N-7	775	8 500
Rhodes & Hicks Drlg Corp	1	rotary, gas-btne	Franks 137	300	5,500
Stice Drlg Co	1	rotary, btne-gas	Unit U-15	496	7,500
Borden County					
Cactus Drlg Corp of Tex	6	rotary, gas-btne	Unit U-15	300	8,500
	9	rotary, gas-btne	Brwstr N-75	800	12,500
Frisbie & Yancey Drlg Co	2	rotary, gas	Brwstr N7	675	8 500
Charles E Long Jr Inc	3	rotary, dsl	Emsco GA 500	520	10,000
Brazoria County					
Bilbo Redding Drlg Co Inc	4	rotary, gas-LPG	Wilson Giant	580	8,000
Harry T Bryant Drlg Co Ltd	2	rotary, gas-btne	TIW CT 5	400	8 000
Henderson DrlgCorp	3	rotary, gas-btne	Natl CB-75	700	11,000
LibertyDrlg Corp	1	rotary, gas-btne	Natl 75	750	10,000
	3	rotary, gas-btne	Natl 100	1000	13,000
	4	rotary, gas-btne	Emsco GB-500	740	9,000
Prince Drlg Corp	1	rotary, stm	BIW T2	1400	13,000
Brewster County					
Makin Drlg Co	8	rotary, gas-gaso	Wilson Titan	975	12,000
Brown County					
Wes-Tex Drlg Co	4	rotary, btne	Wilson Giant	200	4,000
Caldwell County					
Mac's Drlg Co	1	rotary, gas-btne	Cardwell AH	200	4,000
Calhoun County					
Columbia Drlg Co	2	rotary, gas	Unit U-15	500	8,500
	Bge 4	rotary, gas	Emsco GC-500	600	10,000
C G Glasscock Drlg Co	Bge 6	rotary, dsl	Natl 110	1660	16,000
Miller Bros & Bowling	3	rotary, gas-btne	Emsco GC-500	850	9,000
Neal Drlg Co	1	rotary, gas	Emsco G-500	750	9,500
Callahan County					
Brannon & Murray Drlg Co	2	rotary, gas-LPG	Brwstr N-4	250	5,000
Norman Oil Corp	2	rotary, dsl	Unit U-10	330	5,000
W H Varner Drlg Co	1	cable, gas	B Erie 22-W	75	1,500/cable
Cameron County					
Bilbo-Redding Drlg Co Inc	8	rotary, gas-LPG	Nat 110	1600	12,000
Carson County					
Canadian River Drlg Co	1	rotary, dsl	Unit U-34	300	5,000
Federal Drlg Corp	48L	cable, gaso-gas	B Erie 48L	.....	.....
	36 GK	cable, gas-gaso	B Erie 36GK	.....	.....
Wagner & Wyant Drlg Co Inc	3	rotary, dsl	Unit U-34	175	5,000
	4	rotary, btne	Wilson Giant	350	9,000
Cass County					
Delta Drlg Co	15	rotary, gas-btne	Unit U-15	530	8,000
Cherokee County					
Delta Drlg Co	17	rotary, gas-btne	Emsco J-1100	1020	15,000
Trant Drlg Co	3	rotary, stm	.....	.....	15,000
Clay County					
Harvey Drlg Co	5	rotary, gas-btne	Wilson Giant Roadmaster	750	8,500
E W Moran Drlg Co	4	rotary, gas	Unit U-15	300	7,500
Cochran County					
B L McFarland Inc	11	rotary, gas	Natl 100	1000	12,000
Coleman County					
Burger-Raiborn Drlg Co	1	rotary, gas	Wilson Super	225	3,500
Colorado County					
Bilbo-Redding Drlg Co Inc	3	rotary, stm	Emsco UBLS 54-10	1050	12,500
Harry T Bryant Drlg Co Ltd	1	rotary, gas-btne	Unit U-15	400	8,000
Rowan Drlg Co Inc	4	rotary, gas	Natl 75	900	11,000
Cooke County					
Berry Drlg Co	1	rotary, dsl	Wilson Giant	350	6,500
Brown & Martin Drlg Co	1	rotary, btne	Wilson Giant	230	5,500
	2	rotary, btne	WKM	150	1,500
G&T Drlg Co	1	rotary, dsl	.....	250	3,000
Gene McCutchin	5	rotary, gas	Wilson Giant	236	6,500
Cottle County					
West Central Drlg Co	7	rotary, gaso-btne	Wilson Giant	225	5,000

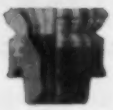
Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Crane County					
Aldridge & Stroud Inc	4	cable, LPG	Ft Wrth Spr D	.....	.....
	9	cable, LPG	Ft Worth Jumbo J	.....	.....
Concho Drlg Co	1	rotray, gas-btne	Franks M5000	225	5,000/3½
Carey & Parker Inc	2	cble, gs-gso-btne	Cardwell RL	.....	10,000/cable
DavidsonDrlg Co Inc	B	rotary, btne	Wilson Titan	630	10,000
Delta Gulf Drlg Co	6	rotary, gas-btne	Emsco J-750	800	9,500
Lloyd R French Co	2	rotary, gas-btne	Unit U-15	675	7,500
Great Western Drlg Co	11	rotary, dsl	.....	.....	9,000
Guadalupe Drlg Co	1	rotary, gas-btne	Ideco M1000	700	10,000
Johnn Drlg Co	2	rotary, gas	Unit U-15	375	7,500
	4	rotary, gas	Unit U-15	375	8,500
	7	rotary, gas	Brwstr N-4	185	5,500
Laughlin-Porter Drlg Co Inc	1	rotary, gas	Natl 50	800	7,000
	3	rotary, gas	Natl T-20	416	5,000
Lee Drlg Co	1	rotary, gas-gaso	Natl 50	700	8,000
	2	rotary, gas-gaso	Natl 50	700	8,000
	4	rotary, gas-gaso	Natl 75	700	10 000
M&J Inc	14	rotary, gas	Cardwell RL	15	3,500
McDaniel & Beecherl Drlg Co	10	rotary, gas-gaso	.....	.....	10,000
B L McFarland Inc	5	rotary, gas	Brwstr N-75	700	10,000
	10	rotary, gas	Natl 50	500	7,000
Rowan Drlg Co Inc	22	rotary, gas	Natl 50	600	7,000
Crockett County					
Bolin Oil Co & D H Bolin	1	rotary, gas	Wilson Super	225	3,500
	7	rotary, gas	Beth S-50	225	4,500
Pool & Gerlich Drlg Co	A	rotary, gas	Unit U-34	260	5,000
	B	rotary, gas	Unit U-34	260	5 000
	C	rotary, gas	Emsco G-250	350	6,000
Urice Drlg Co	5	rotary, gas-gaso	Wilson Giant	350	7,500
	6	rotary, gas-gaso	Wison Super	325	3,000
Dallam County					
Wagner & Wyant Drlg Co Inc	2	rotary, dsl	Unit U-15	300	8,000
Walker Brothers Drlg	1	cable, dsl	Mayhew 1000	.....	.....
Dawson County					
Frisbie & Yancey Drlg Co	4	rotary, gas	Unit U-15	1000	9,000
Kerr-McGee Oil Ind Inc	34	rotary-dsl	Franks LT	220	5 000
Carl B King Drlg Co of Tex	1	rotary, gas-gaso	Natl 100	1000	13,500
Warton Drlg Co	3	rotary, gas	Natl 110	600	14,000
De Witt County					
Del Mar Drlg Co	4	rotary, stm	BIW 11	800+	10,000
Southland Drlg Co	3	rotary, gas-btne	Cardwell O	975	10,000
Duval County					
General Well Drlg Inc	3	rotary, gas-btne	Beth	400	5,000
Gilmour Drlg Co	1	rotary, gas	Wilson Giant	375	6,000
J&C Drlg Co	6	rotary, gas-btne	Natl 50	350	7,500
Miller Bros & Bowling	1	rotary, gas-btne	Emsco G-300	495	5,500
Rock Hill Drlg Co	3	rotary, gas-gaso	Unit U-15	500	9,000
Eastland County					
Irish Drlg Co Inc	2	rotary, btne	Wichtex R-3	280	3,000
	4	rotary, btne	Wichtex R-5	360	4,000
Kent & Preston	2	cable, btne	.....	.....	4,000/cable
Fred Pool Drlg Co	3	rotary, gas	Brwstr N-3	225	4,000
Varner-Neill Drlg Co	1	rotary, gas	Wilson Giant	500	6,000
Ector County					
Alvon Drlg & Exploration Co	1	rotary, dsl	Natl 50A	370	8,500
Arrow Drlg Co	17	rotary, gas	Emsco 1250	1260	14,000
Cactus Drlg Corp of Texas	8	rotary, gas-btne	Brwstr N-7	500	9,000
	4	rotary, gas-btne	Oi Well 76	800	12,500
	5	rotary, gas-btne	Natl 75	500	10,000
Carey & Parker Inc	4	cble, gs-gso-btne	Cardwell RL	.....	10,000/cable
Davidson Drlg Co Inc	A	rotary, gas-btne	Emsco J-1250	1000	14,000
M J Delaney Co	19	rotary, gas-btne	Emsco J-1250	600	15,000
Delta Gulf Drlg Co	4	rotary, gas-btne	Natl 100	800	12,000
	17	rotary, gas-btne	Natl 50-A	624	7,000
Drlg & Expl Co of Del Inc	14	rotary, gas-elect	Natl 34-10	1100	17,000
Exploration Drlg Co	12	rotary, gas	Nat 125	1200	16,000
Fryer & Hanson Drlg Co	4	rotary, gas-btne	Oil Well 76	1150	12,000
	5	rotary, gas-btne	Unit 15	675	8 000
Helmerich & Payne Inc	25	rotary, gas	Oil Well 96	1100	13,000
Carl B King Drlg Co of Tex	7	rotary, gas	Nat 100	1000	13,500
King-Phillips Inc	1	rotary, gas-gaso	Natl 50	695	7,500
Laughlin-Porter Drlg Co Inc	5	rotary, dsl	Natl 23-9FEB	1080	12,000
	6	rotary, gas	Wilson Titan	1000	14,000
Lowe Drlg Co	2	rotary, gas	Natl 75	750	10 000
M&J Inc	7	rotary, gas	Unit U-34	269	3,500
Makin Drlg Co	5	rotary, gas-gaso	Wilson Titan	650	8,000
Milhoan Drlg Co	7	rotary, gas	Oil Well 76	600	8,000

RECTOR type "M"

..the Tubing Head that's WAY ahead ..in Flexibility

MANDREL HANGERS

Type "A" Mandrel Hanger threaded for EUE or regular tubing.



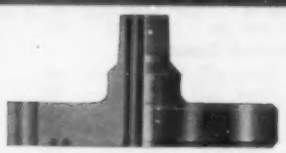
Type "M" Stripper for tubing heads with locking screws.

Type "A-O" Mandrel Hanger threaded, also grooved for locking screws. The "O" Ring serves as temporary seal.

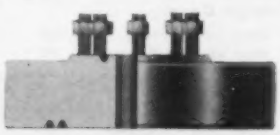
Type "WM" Wrap-Around Mandrel. It is hinged to wrap around tubing; also grooved for locking screws.

Type "C" "Slick Joint" Mandrel grooved for locking screws. The "O" Ring serves as temporary seal.

BONNETS

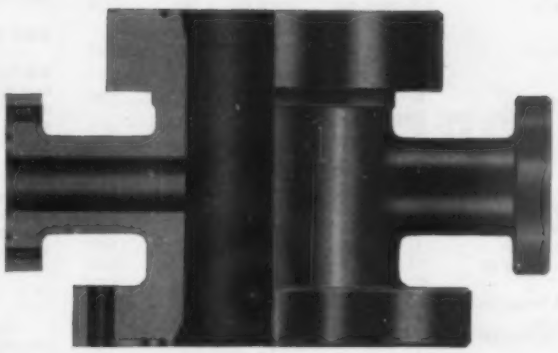


Male threaded bonnet also available with underside female threaded to hang tubing.



Studded bonnet also available with underside female threaded to hang tubing.

Spool-type bonnet also available with underside female threaded to hang tubing.



The wide range of body types (6), the complete range of pressures (2,000 to 15,000 lb. test), the variety of mandrel hangers and bonnets (10) . . . all of which are interchangeable in the bodies, plus auxiliary equipment, make it possible to select a Rector Type "M" Tubing Head for every well completion condition and preference.

Every one of these heads employs the proven Rector principle of sealing with steel . . . a single API Ring Gasket acting dually as seal and hanger hold-down. There are no soft or resilient seals in these heads to deterioriate, burn out, freeze or contract in extremely low temperatures.

When planning well completions . . . specifying Christmas Trees . . . specify a Rector Type "M" Tubing Head for the utmost in safety and flexibility.

For complete specifications of all Type "M" Tubing Heads, Mandrels and Bonnets, see the Composite Catalog.

RECTOR WELL EQUIPMENT COMPANY INC

MAKING THE OIL INDUSTRY SAFER

1100 NORTH COMMERCE ST. FORT WORTH, TEXAS

Houston Plant: 2210 Commerce St.

REPRESENTATIVES IN ALL ACTIVE FIELDS

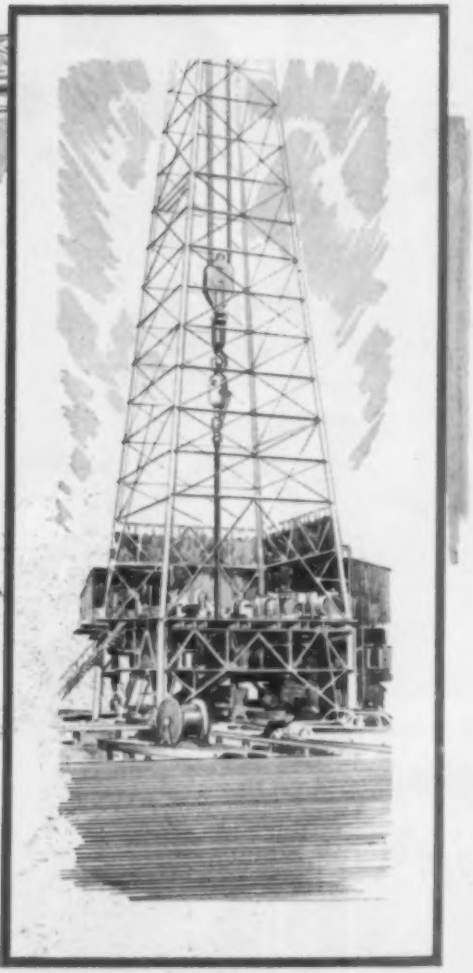
RECTORHEAD RECTORSEAL

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Rheay & Reynolds Drlg Co	3	rotary, gas	.....	400	6,500
	6	rotary, gas	.....	300	5,000
Rowan Drlg Co Inc	16	rotary, gas	Natl 50	504	7,000
	29	rotary, gas	Natl 100	1200	14,000
	31	rotary, gas	Natl 75	900	11,000
A W Thompson Inc	8	rotary, gas	Beth 58	350	7,500
Warton Drlg Co	2	rotrey, dsl	Natl 80	370	8,500
		Fisher County			
Empire Drlg Co	2	rotary, gas	Brwstr N-7	500	9,500
Henson Drlg Co	1	rotary, btne	Unit U-15	825	7,500
J&L Drlg Co Ltd	1	rotary, dsl	Brwstr N-55	.....	7,200
Rheay & Reynolds Drlg Co	4	rotary, gas	.....	350	7,000
Urice Drlg Co	1	rotary, gas-gaso	Emsco GA-500	350	8,500
		Fort Bend County			
Edwards & Bissett	3	rotary, gas	Brwstr N-75	800	10,000
Symons Drlg Co	U-15	rotary, gas	Unit U-15	500	9,000
		Franklin County			
Big Chief Drlg Co	5	rotary, gas	Emsco 1000	985	14,000
		Freestone County			
Smith & Breyer	2	rotary, gaso	Cooper	.....	3,000
		Frio County			
J E Hillier	1	rotary, dsl	Sullivan 300A	200	4,000/3½
		Gaines County			
D-K Drlg Co	3	rotary, gas	Natl 75	500	8,500
M J Delaney Co	26	rotary, stm	Natl T-38	1000+	15,000
Delta Gulf Drlg Co	7	rotary, gas-btne	Nat 50	400	7,000
Exploration Drlg Co	8	rotary, gas	Unit U-15	670	8,000
Great Western Drlg Co	9	rotary, gas-gaso	.....	.....	15,000
	17	rotary, gas-gaso	.....	.....	15,000
Helmerich & Payne Inc	32	rotary, gas	Oil Well 96	1100	13,000
Hissom Drlg Co	2	rotary, gas	Unit U-34	400	6,000
Kerr-McGee Oil Ind Inc	7	rotary, gas	Natl 75	900	11,000
Liano Drlg Co	1	rotary, dsl	Oil Well 96	1100	15,000
Pete Lomax Drlg Co Inc	4	rotary, gas	Beth Twister	225	6,000
B L McFarland Inc	6	rotary, gas	Brwstr N-95	1000	14,000
Robinson Brothers Drlg Co	2	rotary, gas	Brwstr N-75	800	10,000
	3	rotary, gas	Brwstr N-55	300	6,500
Rowan Drlg Co Inc	12	rotary, gas	Natl 100	1260	14,000
Sabine Drlg Co	1	rotary, gas	Natl 110	1524	20 000
Sharp Drlg Co	32	rotary, gas	Beth MC-450	900	12,000
	38	rotary, gas	Beth M-58	700	10,000
A W Thompson Inc	2	rotary, gas	Beth 10-13	650	14,000
Trans-Tex Drlg Co	2	rotary, gas-btne	Unit U-20	1350	13,500
		Galveston County			
Bass Drlg Co	3	rtry, gs-gso-btne	Unit U-34	225	6,500
Bilbo-Redding Drlg Co Inc	Bge 7	rotary, dsl	Oil Well 64-B	550	7,500
C B Webster Drlg Co	1	rotary, gas	CT-5	700	8,000
		Galveston County (offshore)			
Kerr-McGee Oil Ind Inc	43	rotary, dsl	Emsco 1000	1730	14,000
Zapata Off-Shore Co	1	rotary, dsl	Natl 130	1500	16,000
		Garza County			
Calco Drlg Co	3	rotary, gas-btne	Emsco GB-250	275	5,000
		Glasscock County			
Donnell Drlg Co	5	rotary, gas-btne	Unit U-15	650	8,000
Great Western Drlg Co	14	rotary, gas-gaso	.....	.....	7,500
	22	rotary, gas-gaso	.....	.....	15,000
		Goliad County			
Field Drlg Co	4	rotary, dsl	.....	475	5,500
		Gray County			
Baker & Taylor Drlg Co	7	rotary, gas-btne	Natl 55	1200	10,500
Cree Drlg Co Inc	2	rotary, gas-btne	Unit U-10	255	4,500
	8	rotary, gas-btne	Unit U-34	185	5,000
	9	rotary, gas-btne	Unit U-15	350	8,500
Hills & Hills Drlg Co	1	rotary, gas-btne	Emsco GB-350	500	6,500
	2	cable, gas-btne	Wikr-Nr S-33	.....	.....
	3	cable, gas-btne	Wikr-Nr C-34	.....	.....
Holt Brothers Drlg Co	2	rotary, gas-btne	Idaco H-20	540	4,000
Schafer Drlg Co	6	rotary, gas-gaso	Unit U-34	200	5,000
		Grayson County			
M J Delaney Co	9	rotary, stm	Emsco 34-26	800+	10,000
	21	rotary, gas-btne	Wilson Titan	500	9,500
			Emsco		
	25	rotary, stm	UBLS 54	1000+	15,000
	29	rotary, gas-btne	Beth 450	500	11,000
Empire Drlg Co	7	rotary, gas	Wilson Titan	650	13,500
Falcon Soubourd Drlg Co	15	rotary, gas-btne	Unit U-20	900	16,000
	32	rotary, gas-btne	Beth 650	1050	16,000

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Frazier & Goble Drlg Co	1	rotary, dsl	.....	300	5,000
Gibson & Holliman	1	rotary, gas	Unit U-15	500	7,500
	4	rotary, gas	Unit U-15	255	7,500
	6	rotary, gas	Wilson Atlas	750	10,000
Johnn Drlg Co	6	rotary, gas	Brwstr N-95	850	14,000
	8	rotary, gas	Brwstr N-75	500	10,000
Jerry Alex McCutchen Drlg Co	8	rotary, gas	Wilson	600	10,000
Orm Drlg Co	1	rotary, dsl	Unit U-15	600	9,500
R Benton Ross, Inc	1	rotary, dsl	.....	210	3,100
Sharp Drlg Co	35	rotary, gas	Beth M-810	1150	12,800
		Gregg County			
Henderson Drlg Co	1	rotary, gas	Cardwell 5	185	4,500
Tex-Mex Drlg Co	10	rotary, gas	Emsco GB-500	.....	9,000
		Guadalupe County			
R V Muckelroy & Son	1	rotary, dsl	Wilson Mgl	185	4,000
		Hansford County			
Baker & Taylor Drlg Co	2	rotary, dsl	Unit U-15	650	8,000
	3	rotary, dsl	Unit U-15	650	8,000
Drlg & Expl Co of Del Inc	24	rotary, gas-gaso	Franks	350	5,000
Cree Drlg Co Inc	1	rotary, gas-btne	Unit U-15	255	7,500
Great Western Drlg Co	29	rotary, dsl	.....	.....	7,500
Rowan Drlg Co	10	rotary, gas	Beth MC-450	980	9,000
		Harris County			
Burton Drlg Co	10	rotary, gas-gaso	.....	.....	6,000
Columbia Drlg Co	5	rotary, dsl	Unit U-15	400	7,500
Edwards & Bissett	6	rotary, gas	Idaco H-40	400	6,500
Don Hill Well Service Inc	1	rtry, gs-btne-gso	Brwstr N-2	350	3,500
Housh Drlg Co	5	rotary, stm	Emsco UBLS	.....	8,000
	6	rotary, stm	Emsco UBLS	.....	8,000
	7	rotary, stm	Emsco UBLS	.....	8,000
	8	rotary, stm	Emsco UBLS	.....	8,000
	9	rotary, gas-gaso	Unit U-34	185	5,000
Liberty Drlg Corp	2	rotary, gas-btne	Unit U-15	675	9,000
Mac Drlg Co	5	rtry, gs-gso-btne	Bath S-45	275	5,000
Meadows & Walker Drlg Co	1	rotary, gas-btne	Oil Well 64	875	8,500
	2	rotary, stm	BIW 72	600+	12,000
Chessher, Sutton & Davis Drlg Co	1	rotary, gas-btne	Oil Well 76	850	10,500
Union of Texas Oil Co	1	rotary, dsl	Unit U-15	500	5,000
WLB Drlg Co	1	rtry, gso-gs-btne	Brwstr N-35	350	3,500
Cornes W Weaver Drlg Co	1	rotary, gas-btne	Oil Well	700	10,500
		Harrison County			
Delta Drlg Co	22	rotary, gas-btne	Unit U-15	530	8,000
Gibson Drlg Co	3	rotary	Wilson Giant	250	6,000
		Hartley County			
Kerr-McGee Oil Ind Inc	1	rotary, gas	Unit U-15	825	10,000
		Haskell County			
Ace Drlg Co	4	rotary, gas	Emsco G-500	680	7,500
E W Moran Drlg Co	1	rotary, gas	Unit U-15	500	7,500
W B Omohundro	4	rotary, btne	Wilson Atas	450	6,000
	9	rotary, btne	Wilson Roodair	550	6,500
Wes-Tex Drlg Co	3	rotary, btne	Unit U-10	380	6,500
		Henderson County			
Delta Drlg Co	7	rotary, stm	Emsco UB-54	750	12,000
L C Peters Drlg Contr	2	rotary, stm	Oil Well 9-P	390	11,000
		Hidalgo County			
Allen & Morris	2	rotary, stm	BIW-11	1350	11,000
Buzzini Drlg Co	7	rotary, gas-btne	Wilson Atlas	850	11,000
Field Drlg Co	3	rotary dsl	.....	605	8,500
Fitzpatrick Drlg Co	1	rotary, stm	Idaco Drdnght	900+	12,000
	2	rotary, gas	Unit U-40	800	10,000
	4	rotary, gas	Beth 650	900	13,000
C G Glasscock Drlg Co	9	rotary, dsl	Nat T-20	400	6,000
		Hockley County			
Great Western Drlg Co	16	rotary, gas-gaso	.....	.....	15,000
Makin Drlg Co	3	rotary, gas-gaso	Wilson Titan	975	13,000
		Houston County			
Henderson Drlg Corp	4	rotary, gas-btne	Natl B-80	1000	12,500
		Howard County			
Bolin Oil Co & D H Bolin	2	rotary, gas	Wilson Spr	225	3,500
Carey & Parker Inc	5	cbl, gs-gso-btne	Cardwell RL	.....	9,000/cable
Carl B King Drlg Co of Tex	11	rotary, gas-gaso	Natl 75	900	11,000
		Hutchinson County			
Cree Drlg Co Inc	3	rotary, gas-btne	Wilson Giant	225	5,000
	4	rotary, gas-btne	Emsco GA-500	350	9,000
	6	rotary, gas-btne	Wilson Giant	225	5,000
	7	rotary, gas-btne	Emsco 250	185	4,500

There are 2 kinds of Macaroni

This kind



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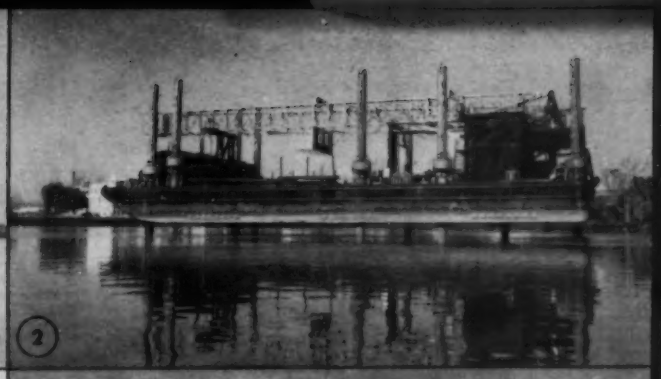

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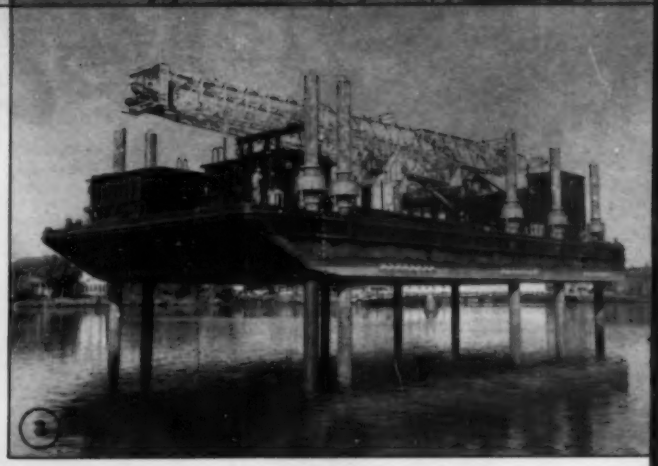

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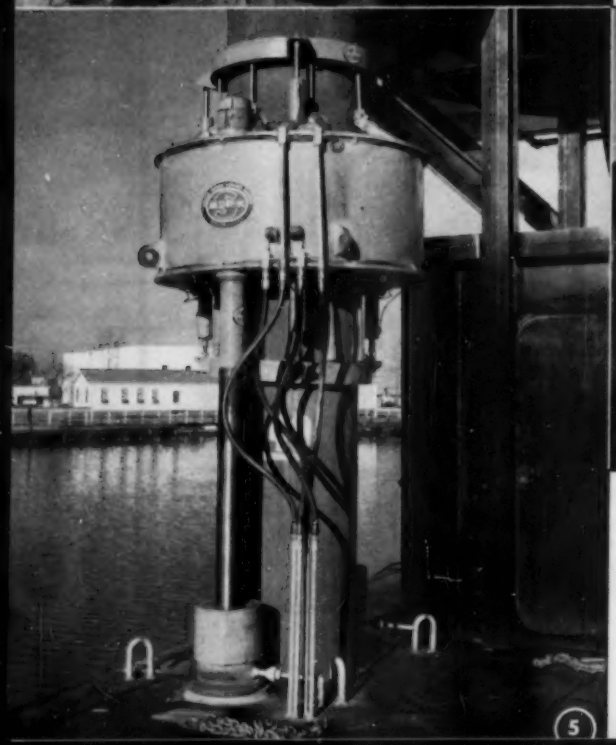

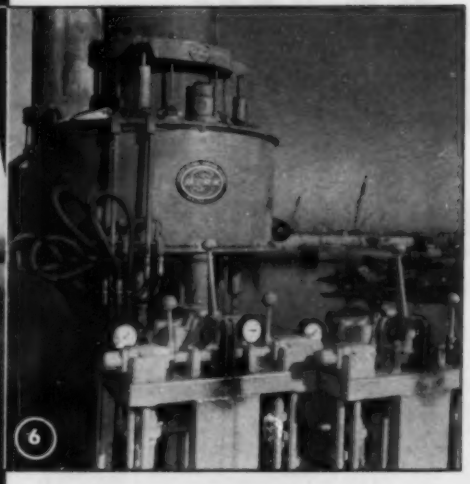

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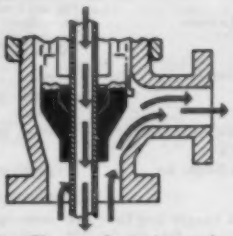
3. Barge can be raised to any desired height.
4. Close-up of jacking mechanism.
5. This unit has 4 ft. piston stroke.
6. Each unit has separate controls.

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Drig & Expl Co of Del Inc	25	rotary, gas-gaso	Wgnr Morbse	350	5,000
Holt Brothers Drig Co	1	cable, gas-btne	B Erie 36-L	140	4,000/cable
Robinson Brothers Drig Co	1	cable, gas	B Erie 48-L	.....	6,500/cable
Service Drig Co	1	rotary, dsl	Unit U-34	320	4,500
	8	rotary, LPG	Unit U-34	300	4,500
Irion County					
Davidson Drig Co Inc	8	rotary, btne	Wilson Giant	315	7,500
Fortune Drig Corp	1	rotary, gas	Beth S-55C	325	7,500
Henson Drig Co	2	rotary, btne	Unit U-15	540	7,500
Jack County					
Allied Exploration Co	1	rotary, btne	Wisn Rdmstr	350	8,000
Leatherwood Drig Co	3	rotary, dsl	Natl T-20	220	6,000
Jackson County					
Bay City Drig Co Inc	2	rotary, gas-btne	Unit U-34	300	5,000
Field Drig Co	1	rotary, dsl	.....	590	8,500
J&C Drig Co	1	rotary, stm	Emsco UBLS	.....	12,000
Lubie Martin Drig Co	1	rotary, gas	Brwstr N-4	300	6,000
Jasper County					
C B Webster Drig Co	2	rotary, gas	Ideco H-7-11	900	12,000
Jefferson County					
The Grey Wolf Drig Co	2	rotary, stm	BIW 12	1050	12,500
Henderson Drig Corp	2	rotary, gas-btne	Unit U-15	450	8,500
Housh Drig Co	1	rotary, stm	Natl	1000+	12,000
	2	rotary, stm	Natl	1000+	12,000
Hunt Drig Co Inc	5	rotary, gas	Beth M-58	450	11,000
Lake Drig Co	1	rotary, gas-LPG	Wilson Giant	370	5,800
	2	rotary, gas-LPG	Allis Chlmrs	180	1,800
Carnes W Weaver Drig Co	2	rotary, gas-btne	Ideco	900	11,000
Jim Hogg County					
Bay City Drig Co Inc	4	rotary, gas-btne	Brwstr N-45	420	7,500
Jim Wells County					
General Well Drig Inc	7	rotary, dsl	Cardwell D	450	6,500
A J Kuenstler Drig Co	1	rotary, dsl	.....	300	7,500
Pyramid Drig Co	2	cable, btne	.....	350	4,000/cable
Jones County					
Ace Drig Co	3	rotary, gas	Natl 50-A	750	7,500
Gore Drig Co	2	rotary, dsl	Beth	320	5,000
Karnes County					
Gilmour Drig Co	2	rotary, gas	Wilson Giant	500	8,500
Hunt Drig Co Inc	1	rotary, gas	Brwstr N-7	625	9,500
Kent County					
Edgar Davis Drig Co	11	rotary, gas-btne	Unit U-15	325	7,500
Lee Drig Co	3	rotary, gas-gaso	Natl 50	700	8,000
Warner & Luttrell Drig Co	3	rotary, dsl	Unit U-15	600	7,500
West Central Drig Co	8	rotary, gas-btne	Wilson Giant	325	8,000
Kleberg County					
Del Mar Drig Co	3	rotary, gas	Natl 75	600	10,500
Kerr-McGee Oil Ind Inc	16	rotary, dsl	Natl 100	990	13,000
Knox County					
Ace Drig Co	2	rotary, gas	Emsco G-500	680	7,500
Henson Drig Co	7	rotary, btne	Cardwell S	275	4,000
LaSalle County					
J&C Drig Co	5	rotary, dsl	Wilson Titan	550	12,500
Liberty County					
Bilbo-Redding Drig Co Inc	5	rotary, gas-LPG	Beth 450	900	11,000
Gilger Drig Co Ltd	3	rotary, stm	Emsco	900+	11,000
Carnes W Weaver Drig Co	5	rotary, gas-btne	Unit U-34	465	5,000
	6	rotary, gas-btne	Brwstr N-7	540	8,500
The Grey Wolf Drig Co	4	rotary, gas-btne	Emsco GB-500	585	9,500
Housh Drig Co	3	rotary, stm	Emsco UBLS	800+	10,000
Hunt Drig Co Inc	3	rotary, gas	Emsco GB-350	525	8,500
Lipscomb County					
Reading & Bates Inc	4	rotary, gas-btne	Natl 75	450	8,000
Rowan Drig Co Inc	2	rotary, gas	Natl 75	840	11,000
Live Oak County					
J&C Drig Co	7	rotary, gas-btne	Emsco 500	400	7,500
The Oil Corp	4	rotary, gas-btne	Unit U-15	300	7,500
Yarborough Drig Co	2	rotary, gas	Cardwell	290	5,000
Loving County					
McDaniel & Beecherl Drig Co	6	rotary, gas-gaso	.....	.....	5,000
	11	rotary, gas-gaso	.....	.....	5,000
Sharp Drig Co	36	rotary, gas	Beth MC-950	1350	15,000
Lynn County					
Carl B King Drig Co of Tex	3	rotary, gas-gaso	Natl 100	1000	13,500
Martin County					
Rowan Drig Co Inc	26	rotary, gas	Natl 100	1200	14,000
Matagorda County					
Bilbo-Redding Drig Co Inc	1	rotary, dsl	Whind 65	550	9,500
Hamman Oil & Ref Co	1	rotary, stm	Ideco Jr Giant	800+	11,000
	4	rotary, gas-btne	Cardwell S	250	3,000
Meadows & Walker Drig Co	3	rotary, gas-btne	Unit U-15	900	8,500
Maverick County					
Bay City Drig Co Inc	1	rotary, gas-btne	Oilwell 52-T	430	6,500
Rowan Drig Co Inc	27	rotary, gas	Natl 125	1200	15,000
McCulloch County					
Kent & Preston	1	cable, dsl	.....	.....	6,000/cable
McMullen County					
Allen & Morris	7	rotary, dsl	Natl 75	780	10,000
	8	rotary, stm	Emsco UBLS	1500	12,000
Midland County					
Delta Gulf Drig Co	8	rotary, gas-btne	Natl 100	900	12,000
Exploration Drig Co	14	rotary, gas	Natl 75-CA	970	11,000
Great Western Drig Co	18	rotary, dsl	.....	.....	15,000
Helmerich & Payne Inc	39	rotary, gas	Oil Well 96	1100	13,000
Johnn Drig Co	3	rotary, gas	Wilson Atlas	650	10,000
King-Phillips Inc	3	rotary, gas-gaso	Ideco H-40D	622	5500
Laughlin-Porter Drig Co Inc	4	rotary, gas	Ideco 1350	1650	14,000
Llano Drig Co	2	rotary, gas	Natl 100	1100	14,000
	3	rotary, gas	Oil Well 96	1200	14,000
	5	rotary, gas	Natl 100	900	14,000
Lowe Drig Co	1	rotary, gas	Unit U-15	500	7,500
A W Thompson Inc	1	rotary, gas	Beth 650	650	12,500
Urice Drig Co	3	rotary, gas-gaso	Emsco GB-500	625	9,000
Zephyr Drig Corp	3	rotary, gas	Beth 950	1260	20,000
	10	rotary, dsl	Beth Tornado	1260	15,000
	11	rotary, gas	Beth 950	1260	20,000
Milam County					
Smith & Breyer	3	rotary, btne-dsl	Spencer	55	4,250
Mitchell County					
Henson Drig Co	5	rotary, btne	Unit U-15	810	7,500
Hissom Drig Co	4	rotary, gas	Unit U-34	400	5,000
	5	cable, gas	Cardwell RL	180	.....
Montague County					
Exploration Drig Co	11	rotary, gas	Beth S-60	300	8,000
Gibson & Holliman	3	rotary, gas	Unit U-15	255	7,500
John W Harris Drig Co	2	rotary, gas	Emsco GC-500	500	8 000
Leatherwood Drig Co	1	rotary, gas	Ideco 750	600	10,000
	2	rotary, gas	Natl T-32	370	7,000
Gene McCutchin	8	rotary, gas	Natl 50	472	8,000
E W Moran Drig Co	2	rotary, gas	Wilson Giant Roadmaster	500	7,500
	3	rotary, dsl	Wilson Giant Roadmaster	285	7,500
W B Omohundro	8	rotary, btne	Wilson Roadair	700	8,000
Montgomery County					
Bilbo-Redding Drig Co Inc	9	rotary, stm	Emsco ECC	1050	15,000
L C Peters Drig Contr	4	rotary, gas-btne	Brwstr N-75	1140	12,000
Navarro County					
Independent Drig Co	1	rotary, btne	Failing 1500	125	2,000/2⅞
Smith & Breyer	1	rotary, btne	Mayhew	46	2,500
Newton County					
Bass Drig Co	1	rtry, gs-gso-btne	Unit U-15	675	10,000
Chessher, Sutton & Davis Drig Co	2	rotary, gas-btne	Oil Well 76	1100	11,500
Prince Drig Co	7	rotary, gas	Oil Well 66	900	10,500
Nolan County					
Arrow Drig Co	4	rotary, gas	Wilson	560	7,000
M J Delaney Co	24	rotary, gas-btne	Beth M-58	500	9,500
Foree Drig Co	2	rotary, gas-btne	Unit U-15	300	7,500
	3	rotary, gas-btne	Unit U-15	325	7,500
	4	rotary, gas-btne	Emsco GA-500	325	7,500
Frisbie & Yancey Drig Co	1	rotary, gas	Unit U-15	450	7,500
Great Western Drig Co	35	rotary, gas-gaso	.....	.....	7,500
Rhoay & Reynolds Drig Co	5	rotary, gas	.....	350	7,000
West Central Drig Co	5	rotary, gaso-btne	Unit U-15	325	7,500
Nueces County					
Allen & Morris	4	rotary, gas-btne	Natl 50	515	8,000
Beard Drig Co	1	rotary, gas-btne	Wilson Giant	500	5,500

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Buzzini Drlg Co	6	rotary, gas-btne	Wilson Giant	1050	10,000
The Don L Clark Drlg Co	2	rotary, gas-btne	Emsco GC-500	700	7,500
Del Mar Drlg Co	1	rotary, stm	BIW 12	900+	11,000
Field Drlg Co	2	rotary, dsl	.....	720	9,000
Frio Drlg Co	1	rotary, gas-btne	CT-5	350	7,500
C G Glasscock Drlg Co	1	rotary, dsl	Natl 75-CB	1200	12,500
	Bge 2	rotary, dsl	Natl 80-B	1200	14,000
	Bge 5	rotary, dsl	Natl 75	1060	12,000
	7	rotary, gas	Unit U-15	800	9,000
	Bge 8	rotary, dsl	Natl 75	1200	12,000
	Bge 10	rotary, dsl	Natl 50	750	9,000
	11	rotary, dsl	Natl 130	2000	18,000
Burdette Graham	1	rotary, gas-btne	Beth M-58	738	9,500
Hunt Drlg Co Inc	4	rotary, gas	Emsco GB-250	485	7,000
Martin & Holmes Oil Well Service Co	1	rtry, dsl-gs-gso	Cardwell	600	7,000
Rock Hill Drlg Co	4	rotary, gas-gaso	Unit U-10	450	7,500
Yarborough Drlg Co	1	rotary, dsl	Wilson	780	9,000
Zapata Off-Shore Co	2	rotary, dsl	Oil Well 96	1850	16,000
Nueces (Offshore) County					
Brewster-Bartle Drlg Co	2	rotary, ds	Oil Well 96	.....	16,000
Ochiltree County					
Baker & Taylor Drlg Co	1	rotary, dsl	Unit U-15	650	8,000
	4A	rotary, gas-btne	Emsco G-500	700	9,500
	6	rotary, gas-btne	Emsco G-450	650	9,000
Brannon & Murray Drlg Co	1	rotary, gas-LPG	Brwstr N-55	350	7,500
Cree Drlg Co Inc	5	rotary, gas-btne	Unit U-40	825	14 000
Empire Drlg Co	8	rotary, gas	Unit U-15	500	8,500
Lynn Drlg Co	4	rotary, gas-btne	Natl 50	300	8,000
	5	rotary, gas-btne	Natl 75	725	10 500
Webster Drlg Co	7	rotary, gas	.....	700	8,500
Orange County					
Gilger Drlg Co Ltd	2	rotary, gas-btne	Beth 400	400	7,500
Panola County					
Delta Drlg Co	6	rotary, stm	Idaco Big Gnt	1200	15,000
Pyburn Langford Drlg Co	2	rotary, gas	Wilson	250	9,000
Tex-Mex Drlg Co	8	rotary, stm	.....	.....	9,000
	11	rotary, stm	.....	1000+	12 000
Wheless Drlg Co	3	rotary, gas-btne	Emsco GB-350	600	7,500
Pecos County					
Donnell Drlg Co	6	rotary, gas-btne	Beth MC-450	975	12,000
Great Western Drlg Co	21	rotary, gas-gaso	.....	.....	15,000
Helmerich & Payne Inc	37	rotary, gas	Oil Well 96	1200	15,000
LH&SA Olson Drlg Co	1	rotary, gas	Natl 50	490	8,000
	2	rotary, gas	Natl 50	490	8,000
	3	rotary, gas	Nat 75	670	10 000
	4	rotary, gas	Emsco G-350	450	7,000
Sharp Drlg Co	37	rotary, gas	Beth MC-450	800	12,000
Reagan County					
Delta Gulf Drlg Co	9	rotary, gas-btne	Natl 100	936	12,000
Carl B King Drlg Co of Tex	2	rotary, gas-gaso	Natl 75	900	11,000
Milhoan Drlg Co	6	rotary, gas	Unit U-15	600	8,000
George W Riley Inc	20	rotary, gas-gaso	Cardwell S	200	4,500
	22	rotary, gas-gaso	Cardwell Tririg	300	5,500
Rowan Drlg Co Inc	30	rotary, gas	Natl 50	640	7,500
Wilbanks & Rutter Drlg Co	1	rotary, gas	Unit U-15	675	8,000
	2	cable, gas	Super J	.....	.....
Red River County					
Talbert & Hughey Drlg Co	2	rotary, dsl	Cardwell L	175	3,500/3½
Refugio County					
Al'sn & Morris	3	rotary, stm	Emsco H-46	1350	9,500
Roberts County					
Hanson Drlg Co	3	rotary, btne	Beth M-58	810	8,000
Schafer Drlg Co	7	rotary, gas-gaso	Idaco H-35	200	5,000
Runnels County					
Brannon & Murray Drlg Co	2	rotary, gas(LPG)	Emsco GA-350	350	6,500
Frank Caraway Drlg Co	1	rotary, btne-gas	Beth S-50	225	5,000
Drill Well Oil Co	1	rotary, btne	Wilson Super	185	4,000
Feree Drlg Co	1	rotary, gas-btne	Unit U-34	325	4,500
Gore Drlg Co	1	rotary, dsl	Shovel Supply	640	7,500
Johnn Drlg Co	5	rotary, gas	Unit U-15	375	8,500
Maxwell Drlg Co	1	rotary, btne-gas	Brwstr N-4	220	4,500
A B Soo Drlg Co Inc	1	rotary, gas	Natl T-20	250	5,000
Tex-Mex Drlg Co	9	rotary, gas	Emsco GB-350	.....	6,000
Wes-Tex Drlg Co	2	rotary, btne	Brwstr N-4	244	5,500
Rusk County					
Delta Drlg Co	2	rotary, gas-btne	Emsco GB-500	680	8,500
San Jacinto County					
Edwards & Bissett	1	rotary, gas	Wilson Giant	800	8,500
San Patricio County					
Buzzini Drlg Co	5	rotary, gas-btne	Wilson Giant	900	9,000
J&C Drlg Co	2	rotary, stm	Emsco H46	.....	9,500
	8	rotary,gas-btne	Beth	450	12,500
The Oil Corp	3	rotary,gas-btne	Cardwell Tririg	280	6,500
Southland Drlg Co	4	rotary, dsl	Brwstr N-7	975	9,500
Schleicher County					
Fortune Drlg Corp	2	rotary, gas	Unit U-15	300	7,500
Hanson Drlg Co	4	rotary, btne	Unit U-15	825	7,500
Tucker Drlg Co	2	rotary, gas	Brwstr N-4	425	6,500
Scurry County					
Caico Drlg Co	1	rotary, gas-btne	Mayhew 3000	225	3,500
Edgar Davis Drlg Co	12	rotary, gas-btne	Wilson Giant	500	10,000
Willard Gladson & Odstroll Bro Drlg Co	1	cable, btne	B Erie 28L	.....	2,400
	2	cable, btne	B Erie 36L	.....	3,400
	3	cable, btne	B Erie 36L	.....	4,500
Graham Drlg Co	1	rotary, dsl	Wilson Super	300	4,500
John Grappe Drlg Co	1	rotary, btne-gas	Beth	520	8,500
	2	rotary, btne-gas	Beth	720	13,000
Shackelford County					
Gore Drlg Co	3	rotary, gas	Sullivan 200-A	254	2,500/2⅞
D L Rose Drlg Contr	1	rotary, btne	Unit U-15	450	7,500
Shelby County					
Arrow Drlg Co	1	rotary, gas	Idaco 1000	860	11,500
Smith County					
Gibson Drlg Co	5	rotary	Wilson Giant	250	6,000
Starr County					
Rock Hill Drlg Co	1	rotary, dsl	Ideal 50	475	8,500
Stephens County					
M&S Drlg Co	2	rotary, btne	Wilson Mogul	370	4,500
Fred Pool Drlg Co	1	rotary, gas	Unit U-15	580	7,500
Stonewall County					
McCutchen & Graham	1	rotary, btne	Wisn Spr Atls	425	11 000
Stice Drlg Co	2	rotary, btne-gas	Unit U-15	600	7,500
Wes-Tex Drlg Co	1	rotary, btne	Cardwell D	300	7,500
	5	rotary, btne	Nat 50	276	8,500
Sutton County					
M J Delaney Co	23	rotary, gas-btne	Wilson Atlas	450	7,000
Great Western Drlg Co	5	rotary, gas-gaso	.....	.....	7,500
Tucker Drlg Co	1	rotary, gas	Brwstr N-55	600	9,500
Taylor County					
Drillers Inc	U-15	rotary, dsl	Unit U-15	.....	7,200
Gogio Bros Drlg Co	1	rotary, btne	Cardwell-KL	200	4,500
	2	rotary, dsl-btne	Wilson Giant	300	6 500
Slim Rea Drlg Co	1	rotary, dsl	Brwstr N-4	275	6,000
	2	rotary, dsl	Brwstr N-4	275	6,000
Sojourner Drlg Corp	1	rotary ,btne	Unit U-15	218	7,500
	2	rotary, dsl	Unit U-15	320	5,000
	3	rotary, dsl	Unit U-15	550	7,500
	4	rotary, btne	Unit U-34	225	4,500
	5	rotary, btne	Natl T-8-S	225	3,250
West Central Drlg Co	2	cable, gaso-btne	Ft Worth Jmbo	.....	2,500
	9	rotary, gaso-btne	Cardwell H	225	3,000
Terry County					
Cactus Drlg Corp of Texas	1	rotary, gas-btne	Natl 110	800	15,000
Great Western Drlg Co	33	rotary, gas-gaso	.....	.....	7 500
Carl B King Co of Tex	4	rotary, gas-gaso	Natl 75	1000	12,500
	10	rotary, gas-gaso	Natl 75	1000	12,500
Throckmorton County					
Harvey Drlg Co	3	rotary, gas-btne	Wisn Mgl Rdr	350	5,000
Tom Green County					
Great Western Drlg Co	2	rotary, gas-gaso	.....	.....	9,000
	4	rotary, dsl	.....	.....	9,000
D L Rose Drlg Contr	2	rotary, dsl	Beth S-55	450	7,500
Tucker Drlg Co	3	rotary, gas	Idaco TC-600	600	9,500
	4	rotary, dsl	Beth J55	610	9,500
Velma Petroleum Corp	6	rotary, gas	Natl 50	1100	9,000
Upton County					
Aldridge & Stroud Inc	5	cable, LPG	B Erie 28L	.....	.....
	6	cable, LPG	Wichita 55	.....	.....
	11	cable, LPG	Wichita 61	.....	.....

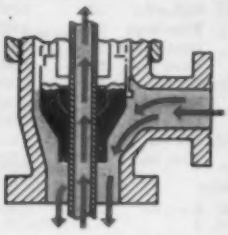
DRILLING WITH AIR OR GAS?



There is a steadily growing use of air or natural gas to replace the mud column in many drilling operations. Advantages include faster drilling rates, more footage per bit, no "lost circulation" problems, and greater production recovery.

The ideal unit for sealing off around the drill string and maintaining safe pressure control is the Shaffer Combination Rotating Blowout Preventer and Stripper. It not only permits the well to be drilled safely, but also it can be adapted to be used as a casing stripper during casing operations to maintain pressure control.

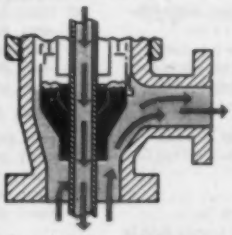
DRILLING WITH REVERSE CIRCULATION?



Reverse circulation is another of the modern drilling techniques that have definite advantages in certain types of formations. By returning the cuttings through the inside of the drill string, higher return velocities are obtained at lower pump pressures (and lower pressures on the formations). The higher velocities insure larger cuttings being returned from the formations, in many cases eliminating need for coring and thus saving rig time. Also by carrying large cuttings away faster, bit life is lengthened and drilling time is reduced.

These and other advantages make Reverse Circulation techniques worth investigating — and here again, the key to proper operation is a Shaffer Combination Rotating Blowout Preventer and Stripper to seal off the drill string and to control circulation pressure while drilling.

NORMAL DRILLING OPERATIONS?



Here again, this Preventer and Stripper insures safety and efficiency to a degree unmatched by any other type of hook-up. The unit seals off around the varying diameters of the drill string — pipe, couplings, tool joints and drill collars — adjusting itself **automatically** to the various diameters and shapes. It even seals safely around such shapes as square, hexagon or octagon kellys. And the seal is automatically maintained as long as the drill string is in the hole. No valves to operate, no levers to move — nothing to remember or forget when pressure emergencies threaten.

GET ALL THE FACTS

on the uses and design features of this unit by sending for the helpful 36 page brochure. It's free to qualified field personnel, engineers and executives!

33 years OF OIL TOOL LEADERSHIP

SHAFFER

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FARMINGTON, NEW MEXICO, Shaffer Tool Works, Post Office Box 1788
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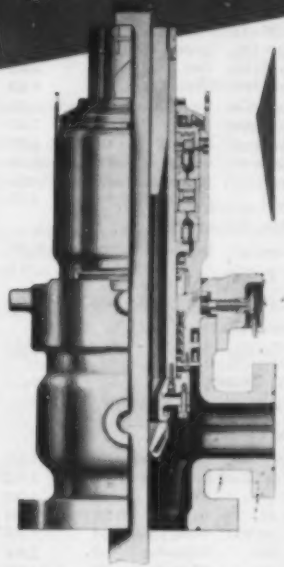
ONE OF THESE

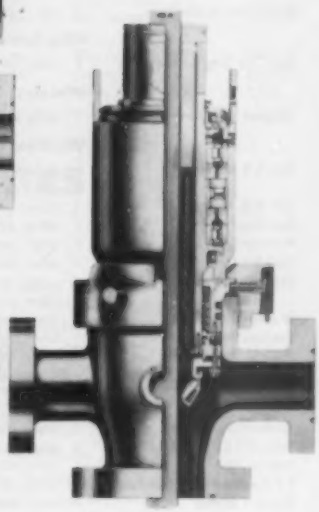
SHAFFER COMBINATION ROTATING BLOWOUT PREVENTERS AND STRIPPERS

fits your particular pressure control requirements!



USE THE TYPE 50

for all kinds of drilling operations, including drilling through 10¾" casing and larger.



USE THE TYPE 51

for blowout protection in slim hole drilling, drilling-in, production jobs, reworking of wells and similar applications.

Shaffer Combination Rotating Blowout Preventers and Strippers are known throughout the industry for the unequalled *automatic* protection they provide against pressure emergencies. Nothing to remember—or forget—when pressure emergencies threaten, because this equipment automatically seals off around the drill string as the tools are lowered into the well . . . *and maintains this pressure-tight seal—without attention—throughout all subsequent drilling operations.*

Whether for big jobs (Type 50) or small (Type 51), both types can be used for the various applications outlined at left.

See your nearest Shaffer representative for complete details on these units. Or write direct.

Send for your free copy of the complete Shaffer Catalog.

See the Shaffer Section of your Composite Catalog.

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Donnell Drlg Co	10	rotary, gas-btne	Beth M-58	650	10,000
Helmerich & Payne Inc	42	rotary, gas	Natl 100	970	12,000
Buck Jones Drlg Co	2	cable	Wikr-Nr 32	.....	.....
	3	cable	Nat 3	.....	.....
	1	cable	Wikr-Noer 33	.....	.....
Lowe Drlg Co	3	rotary, gas	Natl 100	1000	12,500
	11	rotary, gas	Natl 100	1250	12,500
Rowan Drlg Co Inc	25	rotary, gas	Natl 100	1260	14,000
Sharp Drlg Co	20	rotary, gas	Beth MC-950	1050	15,000
Victoria County					
The Dan L Clark Drlg Co	5	rotary, gas-btne	Brwstr N-7	780	8,500
Hunt Drlg Co Inc	2	rotary, stm	Emsco UBLS	750	10,500
Rock Hill Drlg Co	2	rotary, dsl	Ideal 50A	475	8,500
Southland Drlg Co	2	rotary, gas-btne	Unit U-15	700	9,000
Ward County					
Aldridge & Stroud Inc	1	cable, LPG	B Erie 36L	.....	.....
	2	cable, LPG	B Erie 36L	.....	.....
	7	rtry-cable, LPG	Cardwell RL	.....	.....
Carey & Parker Inc	1	cble, gs-gso-btne	Clark 71	.....	4,000
	5	cble, gs-gso-btne	Cardwell RL	.....	9,000
Lloyd R French Co	1	rotary, gas-btne	Unit U-10	300	4,500
Great Western Drlg Co	38	rotary, gas-gaso	.....	.....	7,500
Hissom Drlg Co	3	rotary, gas	Beth S-60	450	6,500
B L McFarland Inc	4	rotary, gas	Cardwell RL	400	4,500
	9	rotary, gas	Cardwell RL	400	4,500
Warner & Luttrell Drlg Co	4	rotary, dsl	Fmks SAI-5000	300	4,500
Washington County					
Pernie Bailey	2	rotary, gas	Unit U-40	800	11,000
Webb County					
Miller Bros & Bowling	2	rotary, gas-btne	Emsco G-450	570	8,000
Wharton County					
Bay City Drlg Co Inc	3	rotary, gas-btne	Oilwell 66	560	9,000
Wheeler County					
Wagner & Wyant Drlg Co	1	cable, btne	Walker Noer	.....	.....
Wichita County					
Ayers & Burch	1	rtry-cable, btne	Walker-Noer	100	1,500
	2	rotary, btne	Walker-Noer	145	3,000
Jim Fish Drlg Co	1	rotary, gas	Wilson	165	4,000
Garrison Drlg Co	1	rotary, dsl	Franks 500	204	6,000
Harvey Drlg Co	6	rotary, gas-btne	Wilson Giant	500	7,500
Hull Oil Co	1	rotary, btne	Walker-Noer	140	2,000
IRT Drlg & Producing Co	1	rotary, btne	Wilson Giant	225	4,500
	3	rotary, btne	Wilson Super	186	3,000
V. B Omohundro	2	rotary, btne	Wilson Giant	350	4,000
Pontiac Drlg Co of Tex	1	rotary, dsl	Unit U-15	500	9,000
Dwight M Ross Drlg Co	1	rotary, btne-gas	Wilson Atlas	300	7,500
Harold Shappell Drlg Co	1	rotary, gas	Wichtex	185	2,800
Wilbarger County					
Anderson Drlg Co	1	rotary, btne	Wilson Mogul	225	4,000
Bolin Oil Co & D H Bolin	6	rotary, gas	Wlsn Gnt Rdr	350	6,500
Dublin-Kiel	1	rotary, btne	.....	.....	2,500
T V Gorman Drlg Contractor	1	rotary, dsl	Wichtex R-3	200	3,000
Frank T Wolfe	1	rotary, btne	Wilson Mogul	85	2,500
	1	cable,btne	Ft Worth D	100	2,500
Willacy County					
Bass Drlg Co	2	rtry, gs-gso-btne	Unit U-15	675	10,000
Southland Drlg Co	1	rotary, dsl	Emsco GA-350	750	8,500
Wilson County					
Buzzini Drlg Co	1	rotary, gas-btne	TIW-CT5	150	3,000
Winkler County					
Donnell Drlg Co	CT1	cable, gas-btne	Model 61	.....	5,000
	CT3	cable, gas-btne	Model 55	.....	5,000
Helmerich & Payne Inc	9	rotary, gas	Oil Well 96	1200	13,000
Sharp Drlg Co	18	rotary, gas	Beth	1350	15,000
A W Thompson Inc	10	rotary, gas	Clark M-1000	650	12,500
Wise County					
Bolin Oil Co & D H Bolin	4	rotary, gas	Wilson Giant	350	7,500
John W Harris Drlg Co	1	rotary, gas	Houston Prtble	600	6,500
Leatherwood Drlg Co	5	rotary, gas	Wilson Rd-Air	375	4,000
Pan-Tex Drlg Co	1	rotary, gas	Brwstr N-45	350	6,500
Rankin, Karper & Glass	3	rotary, dsl	Beth S-55	400	7,000
Trio Drlg Co	1	rotary, dsl-gas	Wilson Giant	520	8,000
	2	rotary, dsl-gas	Cardwell O	520	8,500
	3	rotary, gas	Wilson Giant	450	6,500
	4	rotary, gas	Natl 50	450	6,500

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Wood County					
Gibson Drlg Co	1	rotary	Wilson Mogul	226	4,500
	2	rotary	Wilson Mgl 42	145	5,000
	4	rotary	Cardwell KL	138	4,000
Jerry Alex McCutchen Drlg Co	5	rotary, gas	Wilson	600	6,500
Woolf & Magee Inc	8	rotary, gas-btne	Beth Tornado	1300	15,000
Yoakum County					
Frisbie & Yancey Drlg Co	6	rotary, gas	Wilson Giant	450	7,000
Great Western Drlg Co	32	rotary, dsl	.....	.....	7,500
Laughlin-Porter Drlg Co Inc	2	rotary, gas	Unit U-15	740	7,500
A W Thompson Inc	5	rotary, gas	Beth 810	650	12,500
Young County					
Bolin Oil Co & D H Bolin	3	rotary, gas	Wilson Giant	350	5,000
	5	rotary, gas	Wilson Mogul	225	4,000
D-D Rig Co	1	rotary, btne	Wilson	145	2,500
R W Darden Drlg Co	1	rotary, gas	Wichtex R-3	145	3,000
Hamilton-Powell Drlg Co	1	rotary, gas	Wilson Mogul	225	4,500
A F Knppnbrgr & K&H Drlg	AFK 1	rotary, gas	Emsco GA-500	350	7,000
	K&H 2	rotary, gas	Wilson Mogul	200	5,000
Lofton Drlg Co	1	rotary, btne	Beth Breeze	300	5,500
M&S Drlg Co	1	rotary, btne	Wilson Giant	370	6,500
Rankin Karper & Glass	2	rotary, dsl	Beth S-55	400	7,000
	5	rotary, dsl	Beth S-45	276	5,500
	6	rotary, gas	Wilson Super	200	3,500
Zapata County					
General Well Drlg Inc	1	rotary, gas-btne	Brwstr N-4	300	5,000
UTAH					
Emery County					
Great Western Drlg Co	23	rotary, dsl	.....	.....	7,500
Grand County					
Mesa Drlg Co Div of Camay Drlg Co	6	rotary, dsl	H&J T-40	260	5,000
Walker Wilson Drlg Co	4	rotary, gas	Natl 50-A	500	8,500
San Juan County					
Anschutz Drlg Co Inc	2	rotary, dsl	Wilson Giant	900	8,500
Carmack Drlg Co	1	rotary, dsl	Nat 50-A	680	8,000
Exploration Drlg Co	16	rotary, gas	Natl 75	625	9,000
Fleeger-Riley Drlg Co Inc	1	rotary, gas	Beth Twister	325	7,500
Great Western Drlg Co	42	rotary, dsl	.....	.....	6,500
Jet Drlg Co Inc	3	rotary, dsl	Brwstr N-75	1000	11,000
H B Lynn Drlg Corp	1	rotary, gas-btne	Natl 50	700	7,500
The R W Rine Drlg Co	2	rotary, dsl	Brwstr N-7	520	8,500
Signal Drlg Co	4	rotary, gas	.....	300	5,000
Uintah County					
Charles M Jameson	1	cable, gas-gaso	B Erie 36-L	.....	.....
Kerr-McGee Oil Ind Inc	23	rotary, gas	Natl 50	650	8 000
	28	rotary, gas	Natl 75	870	11,000
	42	rotary, gas	Natl 75	870	11,000
Mesa Drlg Co Div of Camay Drlg Co	5	rotary, gas	Natl 50-A	680	7,500
Mountain States Drlg Co Inc	15	rotary, gas	Natl 125	1400	15,000
Utah County					
Mountain States Drlg Co Inc	12	rotary, gas-gaso	Emsco PDM-46	600	7,500
Wayne County					
Mesa Drlg Co Div of Camay Drlg Co	1	rotary, gas	Unit U-15	730	8,000
WEST VIRGINIA					
Kanawha County					
Eakle & Holder Drlg Co	3	rotary, dsl	Ideco H-30	300	5,000
Logan County					
Allen Drlg Co	4	cable, gas	.....	.....	5,000
	5	cable, gas	.....	.....	5,000
	6	cable, gas	.....	.....	5,000
Mingo County					
Allen Drlg Co	1	cable, gas	.....	.....	5,000
	2	cable, gas	.....	.....	5,000
	3	cable, gas	.....	.....	5,000
Pleasants County					
Henry Gwaltney Drlg Co	2	rotary, gas-prop	.....	200	3,000
Wetzel County					
Cecil Chisler & Son	1	cable, gas-gaso	B Erie Spddr	.....	4,000
WYOMING					
Campbell County					
Mountain States Drlg Co Inc	14	rotary, dsl	Ideco M-1000	800	10,000

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Carbon County					
Mountain States Drlg Co Inc	6	rotary, dsl	Natl 50	600	7,500
Converse County					
Delison Drlg Co	1	rotary, gas	Emsco GB-500	320	8,500
R L Manning Co	5	rotary, gas-btne	Emsco G-500	750	8,000
Fremont County					
A O Bullock Drlg Co	2	rotary, gas	Cardwell S	225	4,000
R L Manning Co	11	rotary, gas-btne	Emsco J-1000	1145	13,000
	12	rotary, gas-btne	Emsco GA-350	550	7,000
	15	rotary, gas-btne	Emsco GB-250	375	6,000
Signal Exploration Inc	2	rotary, gas	.....	370	7,000
Goshen County					
Miracle-Fifer Drlg Co	2	rotary, btne	.....	300	8,500
Nye & Snell Drlg Co	3	rotary, dsl	Wilson Atlas	500	11,000
Hot Springs County					
Dyer Drlg Co	1	rotary, gas-gaso	Natl T-32	325	6,000
R L Manning Co	4	rotary, gas-btne	Emsco 450	375	7,000
Laramie County					
Brinkerhoff Drlg Co	11	rotary, dsl	Cardwell S	175	3,500
Natrona County					
Dyer Drlg Co	3	rotary, dsl	Failing 66	185	3,500
Anschutz Drlg Co Inc	8	rotary, gas	Unit U-15	900	8 500
	9	rotary, gas	Natl 50-A	800	8 500
R L Manning Co	8	rotary, dsl	Emsco G-500	550	7,500
Mountain States Drlg Co Inc	11	rotary, gas-dsl	Natl 80B	1000	12,500
Prairie Drlg Co	1	cable, dsl	Cardwell RL	.....	.....
	2	cable, gas	Cardwell RL	.....	.....
Niobrara County					
Black Hills Drlg Co Inc	1	rotary, dsl	Emsco GA-350	450	7,500
A O Bullock Drlg Co	1	rotary, gas	Wichtex R5	225	3,500

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Park County					
Big Horn Drlg Co Inc	1	rotary, dsl	.....	220	4,500
Delison Drlg Co	2	rotary, gas	Emsco GA-250-T	255	6,000
Delta Drlg Co	25	rotary, gas-btne	Emsco J-1250	1520	15,000
R L Manning Co	2	rotary, gas-btne high line elec	Emsco 300	600	5,500
	7	rotary, gas-btne	Emsco G-500	750	8 000
	9	rotary, dsl	Natl 50	550	7,500
	16	rotary, gas-btne	Natl T-32	475	6,000
Sublette County					
Signal Drlg Co	2	rotary-dsl	.....	900	12,000
Sweetwater County					
Delta Drlg Co	23	rotary, dsl	Emsco GA-500	520	8 000
Delta Gulf Drlg Co	10	rotary, dsl	Natl 75	600	9,500
R L Manning Co	6	rotary, gas-btne	Emsco GB-800	900	11,000
Mountain States Drlg Co Inc	2	rotary, gas-dsl	Emsco J-750	1000	10,000
Uinta County					
R L Manning Co	10	rotary, gas-btne	Emsco J-750	900	11,000
Washakie County					
Anschutz Drlg Co Inc	4	rotary, gas	Wilson Giant	600	8 500
	7	rotary, gas	Unit U-15	900	8,500
Delison Drlg Co	3	rotary, gas	Emsco GB-500	255	7,500
Mountain States Drlg Co Inc	4	rotary, gas-dsl	Emsco GB-500	600	9,000
Kerr McGee Oil Ind Inc	31	rotary, gas	Natl 100	1000	15,000
Weston County					
Black Hills Drlg Co Inc	2	rotary, dsl	Emsco GA-500	1000	12,000
A O Bullock Drlg Co	3	rotary, gas	Bath Twister	370	7,500
Bob Olds Drlg Co	1	rotary, gas	Emsco GB	365	7,000
	2	rotary, gas	Wisn Rdr Hgl	235	6 000
Progressive Drlg Co Inc	1	rotary, gas	Bath Twister	325	8,000
	2	cable, dsl	.....	.....	.....
A L Schlaikjer	4	rotary, gas	Wisn Gnt Rdr	350	8,000
Perl Smith Drlg Contr	1	cable, gaso	Cardwell	.....	6,000
J D Sprecher	5	rotary, dsl	Brwstr N-45	350	6,500

CANADIAN DRILLING CONTRACTORS

ALPHABETICAL LISTING

Arrow Drilling Co., Canada, Ltd.
202 Oil Exchange B'dg.
Calgary, Alberta, Canada

Peter Bawden Drilling, Ltd.
810-A First St. W.
Calgary, Alberta, Canada

B.M.G. Drilling, Ltd.
9916 109th St.
Edmonton, Alberta, Canada.

Commonwealth Drilling Co., Ltd.
122 Eighth Ave. W.
Calgary, Alberta, Canada

Coultis Drilling, Ltd.
1724 Suffolk St.
Calgary, Alberta, Canada

Devon Drilling Co., Ltd.
703 Fifth St. W.
Calgary, Alberta, Canada

Dominion Drilling Co., Ltd.
401 Petroleum Bldg.
Edmonton, Alberta, Canada

Double "A" Drilling Co., Ltd.
709 Eighth Ave. W.
Calgary, Alberta, Canada

General Petroleums of Canada, Ltd.
224 Ninth Ave. W.
Calgary, Alberta, Canada

Hi-Tower Drilling Co., Ltd.
400 Lancaster Bldg.
Calgary, Alberta, Canada

Hunter Drilling, Ltd.
602 Seventh Ave. W.
Calgary, Alberta, Canada

LeBlanc & Fils
195 Blvd. Des Laurentides Pont-Viau
Colaval, Quebec, Canada.

J. W. McKenzie Drilling, Ltd.
152 First Ave. S.
Saskatoon, Saskatchewan, Canada

Moore Drilling Co., Ltd.
Sixth Floor Petroleum Bldg.
Calgary, Alberta, Canada

Parker Drilling Co. of Canada, Ltd.
409 Eighth Ave. W.
Calgary, Alberta, Canada

Patterson & Culver
Box 92
Dunnville Ontario Canada

Precision Drilling Co., Ltd.
1134 Eighth Ave. W.
Calgary, Alberta, Canada

Reading and Bates Drilling Co., Ltd.
Royal Bank Bldg.
Calgary, Alberta, Canada

Rio Palmer Oils, Ltd.
304 Royal Bank Bldg.
Calgary, Alberta, Canada

St. Eustache Well Drillers
2204 Oka Road, R.R. 2
St. Eustache, Quebec, Canada

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
ALBERTA PROVINCE					
Devon Drlg Co Ltd	1	rotary, dsl	Emsco GA-500	700	8,000
	2	rotary, dsl	Emsco GA-350	1050	6,500
	3	rotary, dsl	Emsco GB-500	700	8,500
Bashaw					
Dominion Drlg Co Ltd	3	rotary, dsl	Natl T-32	600	5,000

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Big Valley					
Commonwealth Drlg Co Ltd	16	rotary, dsl	Emsco GB-350	560	6,500
Bistcho					
Arrow Drlg Co (Tulsa, Okla.)	7	rotary, gas	Emsco SCO	750	8,500
Black Diamond					
Commonwealth Drlg Co Ltd	23	rotary, dsl	Emsco GC-500	865	8,500

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Donnell Drlg Co	10	rotary, gas-btne	Beth M-58	650	10,000
Helmerich & Payne Inc	42	rotary, gas	Natl 100	970	12,000
Buck Jones Drlg Co	2	cable	Wlkr-Nr 32	.....	.....
	3	cable	Nat 3	.....	.....
	1	cable	Wlkr-Neer 33	.....	.....
Lowe Drlg Co	3	rotary, gas	Natl 100	1000	12,500
	11	rotary, gas	Natl 100	1250	12,500
Rowan Drlg Co Inc	25	rotary, gas	Natl 100	1260	14,000
Sharp Drlg Co	20	rotary, gas	Beth MC-950	1050	15,000
Victoria County					
The Dan L Clark Drlg Co	5	rotary, gas-btne	Brwstr N-7	780	8,500
Hunt Drlg Co Inc	2	rotary, stm	Emsco UBLS	750	10,500
Rock Hill Drlg Co	2	rotary, dsl	Ideal 50A	475	8,500
Southland Drlg Co	2	rotary, gas-btne	Unit U-15	700	9,000
Ward County					
Aldridge & Stroud Inc	1	cable, LPG	B Erie 36L	.....	.....
	2	cable, LPG	B Erie 36L	.....	.....
	7	rtry-cable, LPG	Cardwell RL	.....	.....
Carey & Parker Inc	1	cble, gs-gso-btne	Clark 71	.....	4,000
	5	cble, gs-gso-btne	Cardwell RL	.....	9,000
Lloyd R French Co	1	rotary, gas-btne	Unit U-10	300	4,500
Great Western Drlg Co	38	rotary, gas-gaso	.....	.....	7,500
Hissom Drlg Co	3	rotary, gas	Beth S-60	450	6,500
B L McFarland Inc	4	rotary, gas	Cardwell RL	400	4,500
	9	rotary, gas	Cardwell RL	400	4,500
Warner & Luttrell Drlg Co	4	rotary, dsl	Frnks SAI-5000	300	4,500
Washington County					
Pernie Bailey	2	rotary, gas	Unit U-40	800	11,000
Webb County					
Miller Bros & Bowling	2	rotary, gas-btne	Emsco G-450	570	8,000
Wharton County					
Bay City Drlg Co Inc	3	rotary, gas-btne	Oilwell 66	560	9,000
Wheeler County					
Wagner & Wyant Drlg Co	1	cable, btne	Walker Neer	.....	.....
Wichita County					
Ayers & Burch	1	rtry-cable, btne	Walker-Neer	100	1,500
	2	rotary, btne	Walker-Neer	145	3,000
Jim Fish Drlg Co	1	rotary, gas	Wilson	165	4,000
Garrison Drlg Co	1	rotary, dsl	Franks 500	204	6,000
Harvey Drlg Co	6	rotary, gas-btne	Wilson Giant	500	7,500
Hull Oil Co	1	rotary, btne	Walker-Neer	140	2,000
IRT Drlg & Producing Co	1	rotary, btne	Wilson Giant	225	4,500
	3	rotary, btne	Wilson Super	186	3,000
W B Omohundro	2	rotary, btne	Wilson Giant	350	4,000
Pontiac Drlg Co of Tex	1	rotary, dsl	Unit U-15	500	9,000
Dwight M Ross Drlg Co	1	rotary, btne-gas	Wilson Atlas	300	7,500
Harold Shappell Drlg Co	1	rotary, gas	Wichtex	185	2,800
Wilbarger County					
Anderson Drlg Co	1	rotary, btne	Wilson Mogul	225	4,000
Bolin Oil Co & D H Bolin	6	rotary, gas	Wlsn Gnt Rdr	350	6,500
Dublin-Kiel	1	rotary, btne	.....	.....	2,500
T V Gorman Drlg Contractor	1	rotray, dsl	Wichtex R-3	200	3,000
Frank T Wolfe	1	rotary, btne	Wilson Mogul	85	2,500
	1	cable,btne	Ft Worth D	100	2,500
Willacy County					
Bass Drlg Co	2	rtry, gs-gso-btne	Unit U-15	675	10,000
Southland Drlg Co	1	rotary, dsl	Emsco GA-350	750	8,500
Wilson County					
Buzzini Drlg Co	1	rotary, gas-btne	TIW-CT5	150	3,000
Winkler County					
Donnell Drlg Co	CT1	cable, gas-btne	Model 61	.....	5,000
	CT3	cable, gas-btne	Model 55	.....	5,000
Helmerich & Payne Inc	9	rotary, gas	Oil Well 96	1200	13,000
Sharp Drlg Co	18	rotary, gas	Beth	1350	15,000
A W Thompson Inc	10	rotary, gas	Clark M-1000	650	12,500
Wise County					
Bolin Oil Co & D H Bolin	4	rotary, gas	Wilson Giant	350	7,500
John W Harris Drlg Co	1	rotary, gas	Houston Prtble	600	6,500
Leatherwood Drlg Co	5	rotary, gas	Wilson Rd-Air	375	4,000
Pan-Tex Drlg Co	1	rotary, gas	Brwstr N-45	350	6,500
Rankin, Karper & Glass	3	rotary, dsl	Beth S-55	400	7,000
Trio Drlg Co	1	rotary, dsl-gas	Wilson Giant	520	8,000
	2	rotary, dsl-gas	Cardwell O	520	8,500
	3	rotary, gas	Wilson Giant	450	6,500
	4	rotary, gas	Natl 50	450	6,500

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Wood County					
Gibson Drlg Co	1	rotary	Wilson Mogul	226	4,500
	2	rotary	Wilson Mgl 42	145	5,000
	4	rotary	Cardwell KL	138	4,000
Jerry Alex McCutchen Drlg Co	5	rotary, gas	Wilson	600	6,500
Woolf & Magee Inc	8	rotary, gas-btne	Beth Tornado	1300	15,000
Yoakum County					
Frisbie & Yancey Drlg Co	6	rotary, gas	Wilson Giant	450	7,000
Great Western Drlg Co	32	rotary, dsl	.....	.....	7,500
Laughlin-Porter Drlg Co Inc	2	rotary, gas	Unit U-15	740	7,500
A W Thompson Inc	5	rotary, gas	Beth 810	650	12,500
Young County					
Bolin Oil Co & D H Bolin	3	rotary, gas	Wilson Giant	350	5,000
	5	rotary, gas	Wilson Mogul	225	4,000
D-D Rig Co	1	rotary, btne	Wilson	145	2,500
R W Darden Drlg Co	1	rotary, gas	Wichtex R-3	145	3,000
Hamilton-Powell Drlg Co	1	rotary, gas	Wilson Mogul	225	4,500
A F Knppnbrgr & K&H Drlg	AFK 1	rotary, gas	Emsco GA-500	350	7,000
	K&H 2	rotary, gas	Wilson Mogul	200	5,000
Lofton Drlg Co	1	rotary, btne	Beth Breeze	300	5,500
M&S Drlg Co	1	rotary, btne	Wilson Giant	370	6,500
Rankin Karper & Glass	2	rotary, dsl	Beth S-55	400	7,000
	5	rotary, dsl	Beth S-45	276	5,500
	6	rotary, gas	Wilson Super	200	3,500
Zapata County					
General Well Drlg Inc	1	rotary, gas-btne	Brwstr N-4	300	5,000
UTAH					
Emery County					
Great Western Drlg Co	23	rotary, dsl	.....	.....	7,500
Grand County					
Mesa Drlg Co Div of Camay Drlg Co	6	rotary, dsl	H&J T-40	260	5,000
Walker Wilson Drlg Co	4	rotary, gas	Natl 50-A	500	8,500
San Juan County					
Anschutz Drlg Co Inc	2	rotary, dsl	Wilson Giant	900	8,500
Carmack Drlg Co	1	rotary, dsl	Nat 50-A	680	8,000
Exploration Drlg Co	16	rotary, gas	Natl 75	625	9,000
Fleeger-Riley Drlg Co Inc	1	rotary, gas	Beth Twister	325	7,500
Great Western Drlg Co	42	rotary, dsl	.....	.....	6,500
Jet Drlg Co Inc	3	rotary, dsl	Brwstr N-75	1000	11,000
H B Lynn Drlg Corp	1	rotary, gas-btne	Natl 50	700	7,500
The R W Rine Drlg Co	2	rotary, dsl	Brwstr N-7	520	8,500
Signal Drlg Co	4	rotary, gas	.....	300	5,000
Uintah County					
Charles M Jameson	1	cable, gas-gaso	B Erie 36-L	.....	.....
Kerr-McGee Oil Ind Inc	23	rotary, gas	Natl 50	650	8 000
	28	rotary, gas	Natl 75	870	11,000
	42	rotary, gas	Natl 75	870	11,000
Mesa Drlg Co Div of Camay Drlg Co	5	rotary, gas	Natl 50-A	680	7,500
Mountain States Drlg Co Inc	15	rotary, gas	Natl 125	1400	15,000
Utah County					
Mountain States Drlg Co Inc	12	rotary, gas-gaso	Emsco PDM-46	600	7,500
Wayne County					
Mesa Drlg Co Div of Camay Drlg Co	1	rotary, gas	Unit U-15	730	8,000
WEST VIRGINIA					
Kanawha County					
Eakle & Holder Drlg Co	3	rotary, dsl	Ideco H-30	300	5,000
Logan County					
Allen Drlg Co	4	cable, gas	.....	.....	5,000
	5	cable, gas	.....	.....	5,000
	6	cable, gas	.....	.....	5,000
Mingo County					
Allen Drlg Co	1	cable, gas	.....	.....	5,000
	2	cable, gas	.....	.....	5,000
	3	cable, gas	.....	.....	5,000
Pleasants County					
Henry Gwaltney Drlg Co	2	rotary, gas-prop	.....	200	3,000
Wetzel County					
Cecil Chisler & Son	1	cable, gas-gaso	B Erie Spddr	.....	4,000
WYOMING					
Campbell County					
Mountain States Drlg Co Inc	14	rotary, dsl	Ideco M-1000	800	10,000

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Carbon County					
Mountain States Drlg Co Inc	6	rotary, dsl	Natl 50	600	7,500
Converse County					
Dellson Drlg Co	1	rotary, gas	Emsco GB-500	320	8,500
R L Manning Co	5	rotary, gas-btne	Emsco G-500	750	8,000
Fremont County					
A O Bullock Drlg Co	2	rotary, gas	Cardwell S	225	4,000
R L Manning Co	11	rotary, gas-btne	Emsco J-1000	1145	13,000
	12	rotary, gas-btne	Emsco GA-350	550	7,000
	15	rotary, gas-btne	Emsco GB-250	375	6,000
Signal Exploration Inc	2	rotary, gas	.....	370	7,000
Goshen County					
Miracle-Fifer Drlg Co	2	rotary, btne	.....	300	8,500
Nye & Snell Drlg Co	3	rotary, dsl	Wilson Atlas	500	11,000
Hot Springs County					
Dyer Drlg Co	1	rotary, gas-gaso	Natl T-32	325	6,000
R L Manning Co	4	rotary, gas-btne	Emsco 450	375	7,000
Laramie County					
Brinkerhoff Drlg Co	11	rotary, dsl	Cardwell S	175	3,500
Natrona County					
Dyer Drlg Co	3	rotary, dsl	Failing 66	185	3,500
Anschutz Drlg Co Inc	8	rotary, gas	Unit U-15	900	8 500
	9	rotary, gas	Natl 50-A	800	8 500
R L Manning Co	8	rotary, dsl	Emsco G-500	550	7,500
Mountain States Drlg Co Inc	11	rotary, gas-dsl	Natl 80B	1000	12,500
Prairie Drlg Co	1	cable, dsl	Cardwell RL	.....	.....
	2	cable, gas	Cardwell RL	.....	.....
Niobrara County					
Black Hills Drlg Co Inc	1	rotary, dsl	Emsco GA-350	450	7,500
A O Bullock Drlg Co	1	rotary, gas	Wichtax R5	225	3,500

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Park County					
Big Horn Drlg Co Inc	1	rotary, dsl	.....	220	4,500
Dellson Drlg Co	2	rotary, gas	Emsco GA-250-T	255	6,000
Delta Drlg Co	25	rotary, gas-btne	Emsco J-1250	1520	15,000
R L Manning Co	2	rotary, gas-btne high line elec	Emsco 300	600	5,500
	7	rotary, gas-btne	Emsco G-500	750	8 000
	9	rotary, dsl	Natl 50	550	7,500
	16	rotary, gas-btne	Natl T-32	475	6,000
Sublette County					
Signal Drlg Co	2	rotary-dsl	.....	900	12,000
Sweetwater County					
Delta Drlg Co	23	rotary, dsl	Emsco GA-500	520	8 000
Delta Gulf Drlg Co	10	rotary, dsl	Natl 75	600	9,500
R L Manning Co	6	rotary, gas-btne	Emsco GB-800	900	11,000
Mountain States Drlg Co Inc	2	rotary, gas-dsl	Emsco J-750	1000	10,000
Uinta County					
R L Manning Co	10	rotary, gas-btne	Emsco J-750	900	11,000
Washakie County					
Anschutz Drlg Co Inc	4	rotary, gas	Wilson Giant	600	8 500
	7	rotary, gas	Unit U-15	900	8,500
Dellson Drlg Co	3	rotary, gas	Emsco GB-500	255	7,500
Mountain States Drlg Co Inc	4	rotary, gas-dsl	Emsco GB-500	600	9,000
Kerr McGee Oil Ind Inc	31	rotary, gas	Natl 100	1000	15,000
Weston County					
Black Hills Drlg Co Inc	2	rotary, dsl	Emsco GA-500	1000	12,000
A O Bullock Drlg Co	3	rotary, gas	Bath Twister	370	7,500
Bob Olds Drlg Co	1	rotary, gas	Emsco GB	365	7,000
	2	rotary, gas	Wisn Rdr Mgl	235	6 000
Progressive Drlg Co Inc	1	rotary, gas	Bath Twister	325	8,000
	2	cable, dsl	.....	.....	.....
A L Schlaikjer	4	rotary, gas	Wisn Gnt Rdr	350	8,000
Perl Smith Drlg Contr	1	cable, gaso	Cardwell	.....	6,000
J D Sprocher	5	rotary, dsl	Brwstr N-45	350	6,500

CANADIAN DRILLING CONTRACTORS

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Coultis Drilling, Ltd.
1724 Suffolk St.
Calgary, Alberta, Canada

Devon Drilling Co., Ltd.
703 Fifth St. W.
Calgary, Alberta, Canada

Dominion Drilling Co., Ltd.
401 Petroleum Bldg.
Edmonton, Alberta, Canada

Double "A" Drilling Co., Ltd.
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Calgary, Alberta, Canada

General Petroleums of Canada, Ltd.
224 Ninth Ave. W.
Calgary, Alberta, Canada

Hi-Tower Drilling Co., Ltd.
400 Lancaster Bldg.
Calgary, Alberta, Canada

Hunter Drilling, Ltd.
602 Seventh Ave. W.
Calgary, Alberta, Canada

LeBlanc & Fils
195 Blvd. Des Laurentides Pont-Viau
Colaval, Quebec, Canada.

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St. Eustache Well Drillers
2204 Oka Road, R.R. 2
St. Eustache, Quebec, Canada

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
ALBERTA PROVINCE					
Devon Drlg Co Ltd	1	rotary, dsl	Emsco GA-500	700	8,000
	2	rotary, dsl	Emsco GA-350	1050	6,500
	3	rotary, dsl	Emsco GB-500	700	8,500
Bashaw					
Dominion Drlg Co Ltd	3	rotary, dsl	Natl T-32	600	5,000

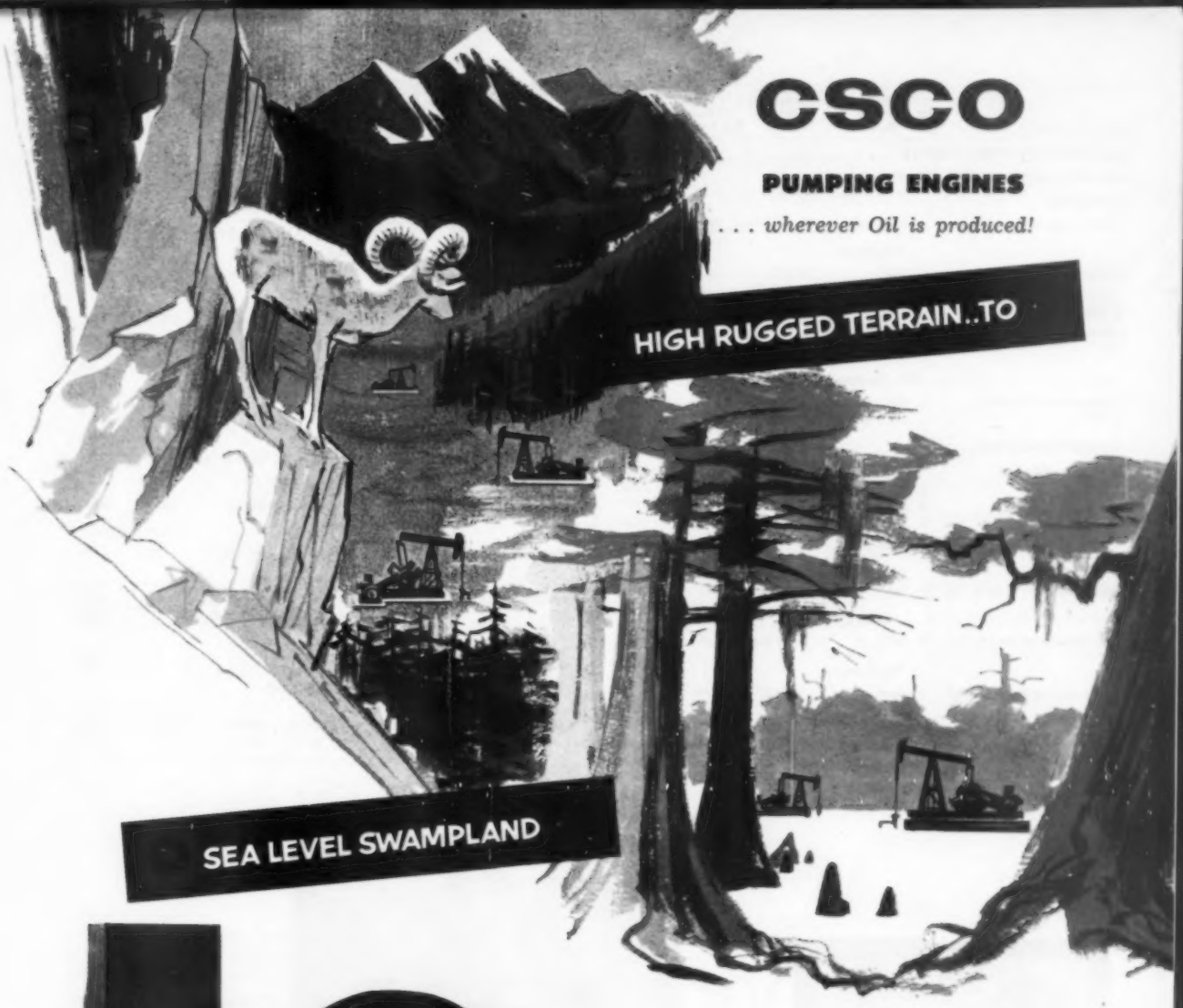
Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Big Valley					
Commonwealth Drlg Co Ltd	16	rotary, dsl	Emsco GB-350	560	6,500
Bistcho					
Arrow Drlg Co (Tulsa, Okla.)	7	rotary, gas	Emsco 500	750	8,500
Black Diamond					
Commonwealth Drlg Co Ltd	23	rotary, dsl	Emsco GC-500	865	8,500

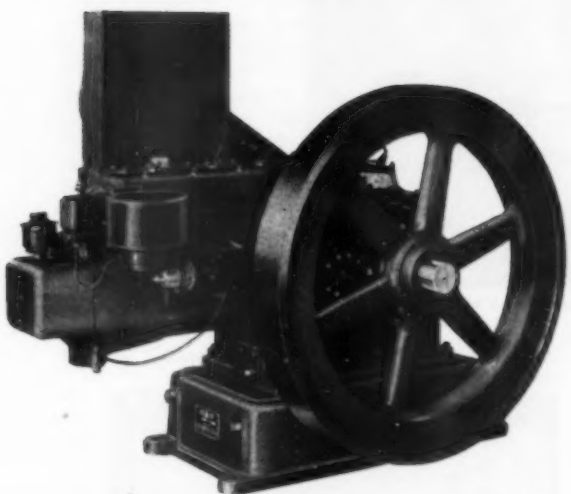
Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
Buck Creek					
Commonwealth Drlg Co Ltd	19	rotary, dsl	Natl 50A	490	8,000
	7	rotary, dsl	Natl 50	750	6,500
	8	rotary, dsl	Brwstr N7	690	8,000
Geni Petrols of Canada Ltd	17	rotary, dsl	.....	.....	7,000
	1	rotary, dsl	.....	.....	6,000
Calgary					
Geni Petrols of Canada Ltd	11	rotary, dsl	.....	.....	10,000
Camrose					
B M G Drlg Ltd	1	rotary, dsl	Cardwell S	275	5,000
Central Alberta					
Coultis Drlg Ltd	1	rotary, dsl	Idaco H-25	238	4,000
Clear Hills					
Parker Drlg Co of Can Ltd	7	rotary, dsl	Natl 55	600	9,000
Compeer					
Precision Drlg Co Ltd	1	rotary, dsl	Idaco H-30-D	276	5,000
Cynthia					
Commonwealth Drlg Co Ltd	21	rotary, dsl	Idaco 7-11	1250	10,500
Drayton Valley					
Commonwealth Drlg Co Ltd	11	rotary, dsl	Idaco H-40	260	5,500
Drumheller					
Parker Drlg Co of Can Ltd	11	rotary, dsl	Natl 50	320	6,500
Erskine					
Commonwealth Drlg Co Ltd	2	rotary, dsl	Natl 50	550	6,000
Hi-Tower Drlg Co Ltd	9	rotary, dsl	Cardwell D	285	5,000
Fenn-Big Valley					
Parker Drlg Co of Can Ltd	12	rotary, dsl	Oil Well 64-B	325	6,500
Giroux Lake					
Parker Drlg Co of Can Ltd	2	rotary, dsl	Natl 75	450	10,000
Grande Prairie					
Arrow Drlg Co (Tulsa, Okla)	26	rotary, gas	Emsco 800	750	12,000
Arrow Drlg Co Canada Ltd	21	rotary, dsl	Emsco J-1000	600	14,000
	26	rotary, dsl	Emsco GB-800	600	13,000
Commonwealth Drlg Co Ltd	20	rotary, dsl	Idaco 7-11	1250	10,500
Halliday					
Commonwealth Drlg Co Ltd	17	rotary, dsl	Emsco GB-350	400	6,000
Hermatton					
Commonwealth Drlg Co Ltd	26	rotary, dsl	Natl 808	1275	12,000
Hi-Tower Drlg Co Ltd	6	rotary, dsl	Oil Well 76	755	12,000
Joffre					
Peter Bawden Drlg Ltd	1	rotary, dsl	Natl T-32	270	5,500
Commonwealth Drlg Co Ltd	3	rotary, dsl	Natl 50	520	6,500
Dominion Drlg Co Ltd		rotary, dsl	Natl 50	450	6,500
Moore Drlg Co Ltd	2	rotary, dsl	Emsco 450	600	7,000
Parker Drlg Co of Can Ltd	8	rotary, dsl	Natl 50	165	6,500
Kevisville					
Commonwealth Drlg Co Ltd	1	rotary, dsl	Natl 110	1350	14,000
Klingstal					
Parker Drlg Co of Can Ltd	9	.....	Natl 125	1200	12,000
Lethbridge					
Geni Petrols of Canada Ltd	2	rotary, dsl	.....	.....	4,800
Nanton					
Hi-Tower Drlg Co Ltd	10	rotary, dsl	Oil Well 76	755	12,000
Peace River					
Arrow Drlg Co Can Ltd	7	rotary, dsl	Emsco GC-500	600	9,000
Pennant Drlg Ltd (Tulsa, Ok)	3	rotary, dsl	Cardwell O	300	7,500
Peter Bawden Drlg Ltd	5	rotary, dsl	Cardwell RL	270	4,500
Commonwealth Drlg Co Ltd	10	rotary, dsl	Cardwell	440	6,000
Geni Petrols of Canada Ltd	4	rotary, dsl	.....	.....	7,000
Pembina					
Arrow Drlg Co (Tulsa, Okla)	6	rotary, gas	Emsco 350	225	7,000
	8	rotary, gas	Emsco 350	225	7,000
	19	rotary, gas	Emsco 350	225	7,000
Arrow Drlg Co Canada Ltd	6	rotary, dsl	Emsco GB-350	250	7,000
Dominion Drlg Co Ltd	1	rotary, dsl	Natl T-32	280	5,000
	2	rotary, dsl	Natl 50-A	560	6,500
Double-A Drlg Co Ltd	2	rotary, dsl	Idaco H-525	800	8,000
Geni Petrols of Canada Ltd	3	rotary, dsl	.....	.....	6,000
	6	rotary, dsl	.....	.....	6,500
	14	rotary, dsl	.....	.....	6,500
Hi-Tower Drlg Co Ltd	1	rotary, dsl	Oil Well 66	525	8,000
	3	rotary, dsl	Oil Well 66	525	8,000
	4	rotary, dsl	Natl 50	350	6,500
	5	rotary, dsl	Natl 50	350	5 000
	7	rotary, dsl	Oil Well 66	525	8,000
	8	rotary, dls	Unit U-15	570	8,000
Hunter Drlg Ltd	2	rotary, dsl	Cardwell	275	6,000
Parker Drlg Co of Can Ltd	4	rotary, dsl	Natl 50	325	6,500
	5	rotary, dsl	Natl 50	320	6,500
	10	rotary, dsl	Natl 50-A	320	7,000
Reading, Bates Drlg Co Ltd	5	rotary, dsl	Natl 50-A	375	7,000
	6	rotary, dsl	Natl 80	375	6,000
	7	rotary, dsl	Natl 50-A	375	7,000
	8	rotary, dsl	Natl 110	1500	13,500
Pouce Coupe					
Commonwealth Drlg Co Ltd	22	rotary, dsl	Natl 50	750	6,500
Rimbey					
Moore Drlg Co Ltd	1	rotary, dsl	Unio U-40	1000	10,000
Pennant Drlg Ltd (Tulsa, Ok)	2	rotary, dsl	Unit U-15	755	8,500
Rocky Mountain					
Arrow Drlg Co Canada Ltd	8	rotary, dsl	Emsco GB-350	250	7,000
	19	rotary dsl	Emsco GB-350	250	7,000
Geni Petrols of Canada Ltd	7	rotary, dsl	.....	.....	13,000
Stettler					
Reading, Bates Drlg Co Ltd	1	rotary, gas-btne	Natl 50-A	300	7,000
Sturgeon Lake					
Peter Bawden Drlg Ltd	2	rotary, dsl	Natl 55	400	8,500
Commonwealth Drlg Co Ltd	9	rotary, dsl	Idaco 700	1020	10,000
Geni Petrols of Canada Ltd	5	rotary, dsl	.....	.....	10,000
Parker Drlg Co Canada Ltd	1	rotary, dsl	Oil Well 76	615	10,000
	3	rotary, dsl	Oil Well 76	765	10,000
Sundre					
Geni Petrols of Canada Ltd	15	rotary, dsl	.....	.....	10,000
	10	rotary, dsl	.....	.....	12,000
Reading, Bates Drlg Co Ltd	3	rotary, dsl	Natl 75	950	8 000
	4	rotary, dsl	Natl 80-B	1100	10,000
Uncas					
Dominion Drlg Co Ltd	4	rotary, dsl	Emsco GB-250	600	5,000
BRITISH COLUMBIA					
Reading, Bates Drlg Co Ltd	2	rotary, gas-dsl	Natl 100	800	11,000
Rio Palmer Oils Ltd	3	rotary, dsl	Natl 80-B	1545	10,000
Arrow Creek					
Commonwealth Drlg Co Ltd	15	rotary, dsl	Brewster N-7	800	8,000
Ft. St. John					
Pennant Drlg Ltd (Tulsa, Ok)	5	rotary, dsl	Unit U-34	300	5,500
MANITOBA					
Owen Drlg Co (O'ton, Tex)	1	rotary, dsl	Cardwell	350	4,000
Virden					
Peter Bawden Drlg Ltd	3	rotary, dsl	Cardwell	270	4,500
	4	rotary, dsl	Cardwell RL	220	4,500
Commonwealth Drlg Co Ltd	12	rotary, dsl	Natl T-32	260	5,500
Coultis Drlg Ltd	2	rotary, dsl	Wilson-Mogul	245	4,000
Moore Drlg Co Ltd	3	rotary, dsl	Brewster N-4	320	4,000
	4	rotary, dsl	Franks 4000	330	3,500
West Butler					
Commonwealth Drlg Co Ltd	18	rotary dsl	Cardwell RL	170	4,500
Whitecourt					
Pennant Drlg Ltd (Tulsa, Ok)	1	rotary, dsl	Unit U-15	755	8,500
	4	rotary, dsl	Cardwell O	590	9,500

CSCO

PUMPING ENGINES

. . . wherever Oil is produced!





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Only CSCO Engines have ALL 4 of these important features:

SMOOTH, STEADY OPERATION . . . The CSCO flywheel inertia provides peak power while the oil damped governor holds the throttle steady — permitting the engine to average the demand, up to its full capacity.

EASY AND SAFE TO START . . . CSCO Engines were designed for oil well pumping — and of top engineering importance was easy and safe starting.

EASY TO SERVICE . . . There's no need to stop a CSCO to check or add oil . . . or water. Less shutdown for servicing.

EASY TO REPAIR . . . CSCO parts needing repair or attention can be removed with a minimum of disturbance of adjacent parts or assemblies.

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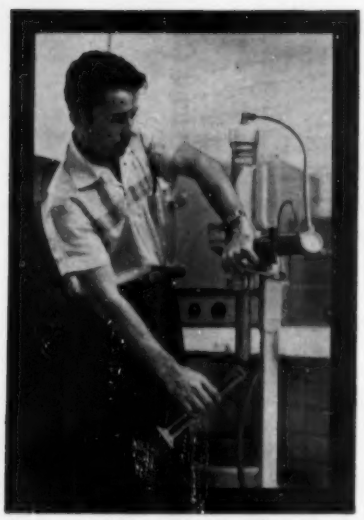
Representatives in All Principal Oil Fields of the World

The Petroleum Industry . . . Since 1859 Helping Make America Great

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
NORTHWEST TERRITORIES					
Geni Petrols of Canada Ltd	F55	rotary, sl	.....	.....	2,500
ONTARIO					
Fon-Par Exp Co Inc (Mich)	2	rotary, dsl	Failing 1500	100	1,500
Niagara					
Patterson & Culver	2	cable	Natl 2	.....	2,500
	1	cable	B. Erie 28-L	.....	2,500
QUEBEC					
LeBlanc & Fils	1	cable	B. Erie 21-W	.....	.....
	2	cable	B. Erie 22-W	.....	.....
St. Eustache					
St Eustache Well Drillers	1	cable, gaso	Armstrong 50-W	35	2,000
	2	cable, gaso	Armstrong 35-W	22	500
SASKATCHEWAN					
Rio Palmer Oils Ltd	1	rotary, dsl	Natl T-32	350	5,000
	2	rotary, dsl	Natl T-55	650	7,500
	4	rotary, dsl	Natl T-20	260	4,000
	5	rotary, dsl	Natl T-32	375	5,000
	6	rotary, dsl	Natl T-12	275	3,000
Alida					
Commonwealth Drlg Co Ltd	25	rotary, dsl	Unit U-34D	425	5,500
Beechy					
Commonwealth Drlg Co Ltd	14	rotary, dsl	Ideco H-40	260	5,500
Buchanan					
Commonwealth Drlg Co Ltd	4	rotary, dsl	Cardwell RL	170	4,500
Carnduff					
Geni Petrols of Canada Ltd	8	rotary, dsl	.....	.....	5,000
Choiceland					
J. W. MacKenzie Drlg Ltd	1	rotary, dsl	Brewster N-4	265	3 500
	2	rotary, dsl	Failing 2500	200	2,500
Coleville					
Precision Drlg Co Ltd	A	rotary, dsl	Ideco H-20-D	276	2,500
Dollard					
Precision Drlg Co Ltd	B	rotary, dsl	Ideco H-30	276	5,000
Esteuan					
Hunter Drlg Ltd	1	rotary, dsl	Cardwell	275	6,000
Hastings					
Commonwealth Drlg Co Ltd	13	rotary, dsl	Emsco GB-350	390	6,500
Laird					
Commonwealth Drlg Co Ltd	5	rotary, dsl	Emsco GB-250	260	5,000
Midale					
Precision Drlg Co Ltd	6	rotary, dsl	Ideco H-30-D	276	5,000
Nottingham					
Commonwealth Drlg Co Ltd	24	rotary, dsl	Natl 50	520	6,000
Richprairie					
Commonwealth Drlg Co Ltd	6	rotary, dsl	Ideco M-750	690	7,000
S. E. Ala. Sask.					
Double-A Drlg Co Ltd	1	rotary, dsl	Ideco H-30	300	4,500
	3	rotary, dsl	Ideco H-40	300	6,000
Steelman					
Geni Petrols of Canada Ltd	9	rotary, dsl	.....	.....	5,500
Swift Current					
Geni Petrols of Canada Ltd	12	rotary, dsl	.....	.....	4,600
Hunter Drlg Ltd	3	rotary, dsl	Cardwell	275	6,000
Precision Drlg Co Ltd	8	rotary, dsl	Natl T-20	276	4,000

Brookfield Viscometer used to measure viscosity of thick fluids.



Pneumatic homogenizer used to create the toughest possible emulsion with oil from the well to be treated and CPC J-Type acid. Testing continues until an acid solution is found which will separate from the oil very quickly after emulsification.

Colorimeter for determining sulphate content of various solutions.

SOME CONTRACT RIGS IN FOREIGN SERVICE

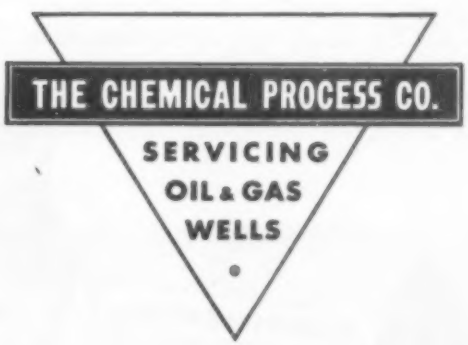
Although no effort was made to obtain location and specifications of drilling rigs located outside the U. S. and Canada, several drilling contractors did send this information. Those rigs are included below.

Contractor's Name	Rig No.	Type Rig and Prime Mover	Drawworks Make and Model	Total HP All Main Mud Pumps	Drilling Depth with 4½" Pipe
ISRAEL					
Pontiac Drlg Co of Tex	2	rotary, dsl	Unit U-15	500	9,000
ITALY					
Compagnia Industrie Metanifere E Affini (Rome, Italy)	2	rotary, dsl	Ideco H-30	260	4,500
	1	rotary, dsl	Ansaldo 2000	900	7,000
NORTH AFRICA					
Delta Drlg Co	1	rotary, dsl	Emsco A-800	1250	11,000
VENEZUELA					
Perforaciones Delta, C A (Caracas, Venezuela)	8	rotary, gas-bine	Cardwell 0	260	4,500
	9	rotary, dsl	Ideal T-12	130	2,500
	10	rotary, dsl	Emsco G-500	600	8,000
	11	rotary, dsl	Emsco GB-800	1000	12,000
	12	rotary, dsl	Emsco J-1250	1560	15,000
	13	rotary, dsl	Emsco J-1250	1040	15,000
Perforaciones Guarico C A (Caracas, Venezuela)	1	rotary, dsl	Ideco H-40-D	260	6,500
	2	rotary, dsl	Ideco H-40-D	260	6,500
	3	rotary, dsl	Failing 2066	260	
	4	rotary, dsl	Ideco H-40-D	260	6,500
	5	rotary, stm	Emsco UBLS	1200	15,000
	6	rotary, dsl	Ideco H-40-D	260	6,500
	7	rotary, dsl	Ideco H-30-D	260	4,500

The research and the engineering processes that have come from The Chemical Process Company Laboratory over the years have made significant contributions to the technology of well stimulation. We maintain one of the most complete and expertly staffed research labs in our industry. Our chemists, petroleum engineers, and geologists are continually developing new products, new processes, and new techniques, which our crews subsequently test in the field. We invest a lot of money in lab and field experiments because we believe that in the long run these projects will be as important to our customers as our day-to-day lab work of analyzing customers' field brines, cores, and cuttings. So it is entirely possible that from our lab itself might come one of the best reasons you could have for doing business with The Chemical Process Company. Nowhere in the oil patch will you find a better outfit — with better men, better equipment, better facilities, or a better insight into the science of oil and gas well stimulation.

a good lab...

to make you a better well



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D+B SUCKER RODS

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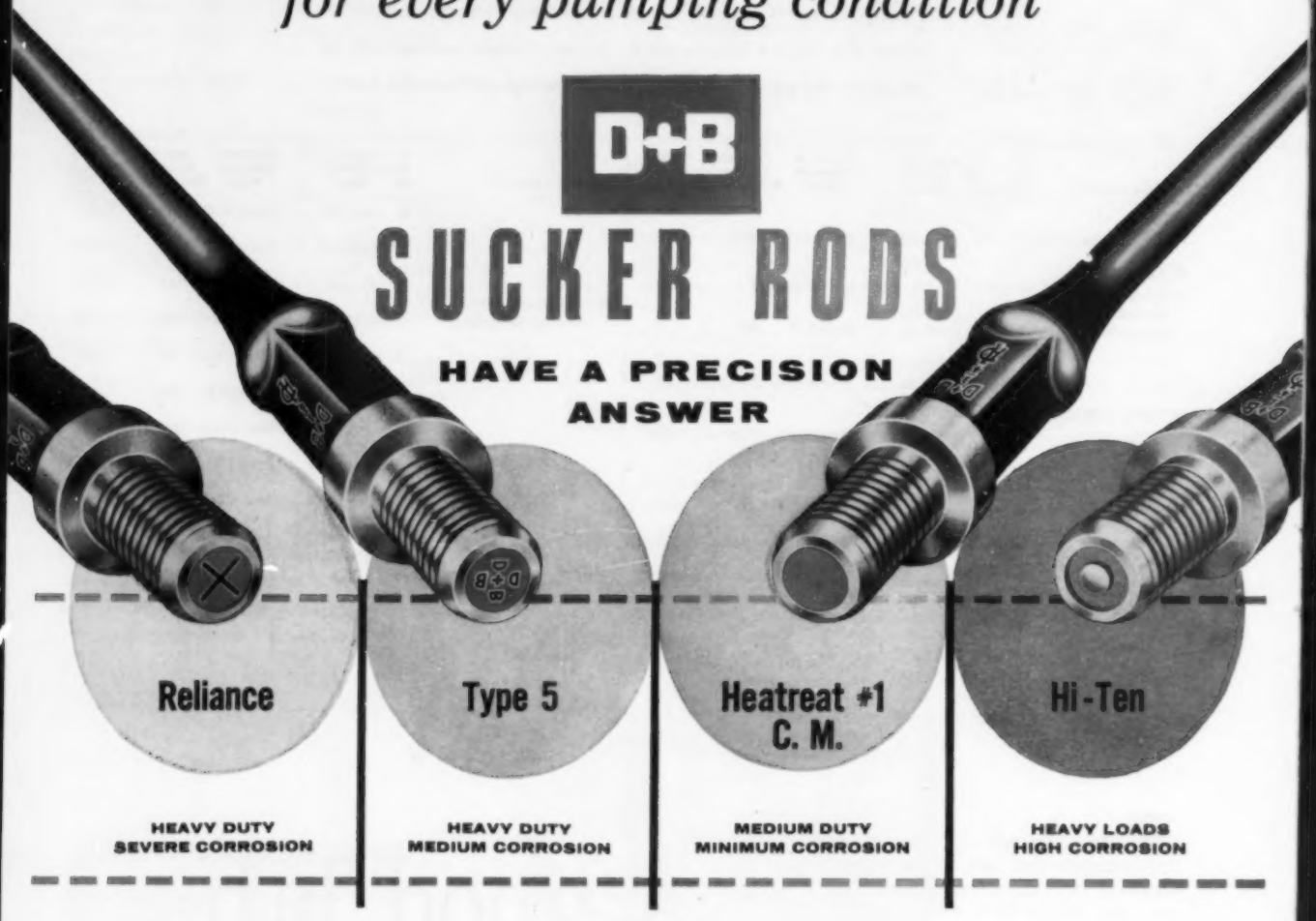

To give you the right combination of strength, ductility, hardness and impact properties, D+B Sucker Rods are made from metallurgically controlled steel, full length heat-treated under accurate factory conditions. Carefully controlled straightening, forging, full length normalizing and drawing, shot blasting, threading and painting operations assure long, trouble free service in the well. Stop in or call today at your nearest CONTINENTAL or D+B store and select from complete stocks.

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SR—604

One-third of Texas Oil Comes from Bonus-free Wells

TEXAS REVIEWS ITS SHUTDOWN - EXEMPT FIELDS

Commission to determine:

- **Number of days that exempt fields can be shut in without damaging formations**
- **Clearer definitions of waste as related to the exempt wells**
- **What factors will determine the exemption qualifications**
- **Fields that can no longer justify position on exemption rolls**

C. R. Graham
Field Editor

CURRENT hearings on the shutdown-exempt oil fields of Texas may be causing much "unwarranted" anxiety, commotion and attention, early reports of the probes indicate.

A review of the bonus-flow fields — those exempt from non-producing days ordered in other areas — began February 1. Hearings commenced with pools in the Texas Railroad Commission's District 3, the upper Texas Gulf Coast, and are continuing one day a week on a pool-by-pool basis.

Aim of the check into the state's 429 exempt fields is a routine effort by the Commission to filter out possible flaws in the distribution of oil production. Current Texas oil flow totals about 3,000,000 bbl daily, and it has been estimated that nearly one-third of the total production comes from the exempt fields.

Depending on whether a producer draws most of his production from the exempt or non-exempt areas, the proceedings will be viewed from different and conflicting vantage points. The Chamber of Commerce of one South Texas city was so aroused by the possibility of changing the status of oil wells in its area that committees were formed and funds solicited "to fight this thing."

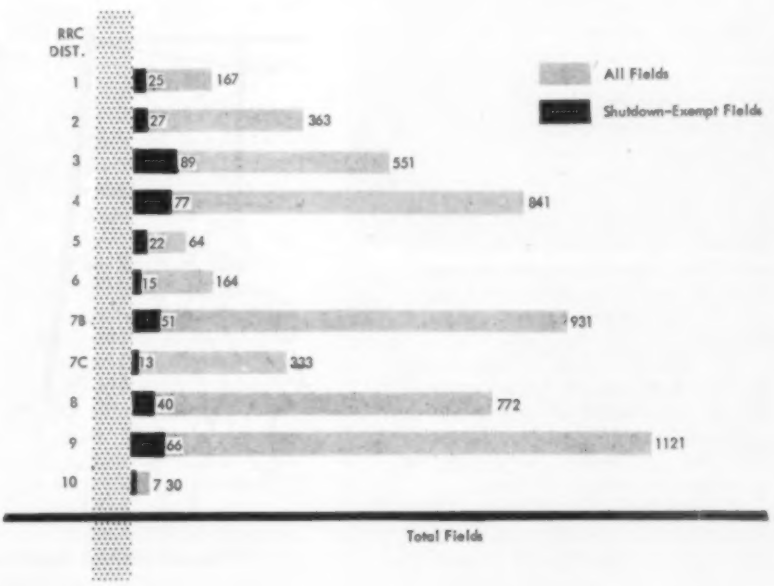
A re-evaluation of these bonus-flow fields, more in line with rules adhered to by a majority of the state's wells is an attempt to increase the number of statewide producing days.

Although reasons for proration exemption are numerous, rapid increases in the number of exempt fields has been largely due to the growing number of secondary recovery and salt dome flank wells. Both enjoy the exemption status. Some operators assert that production from these two categories alone have reached "proportions which suggest that equity is not being accorded non-exempt fields."

To substantially cut back the large flow from exempt fields, the Commission apparently would have to accept new and, very likely, controversial engineering concepts. Present theories on waterflooded wells, for example, hold that temporary shutdowns would damage production to a point that waste would result.

Waterflood production must be placed under some form of shutdown pattern, suggest some operators, as a major portion of the state's production eventually will be drawn from wells of this type. One operator, noting this trend, appeared in Austin recently to protest an exemption request by another producer.

High water-oil ratios, sand problems, and steeply-dipped formations are main reasons for bonus flow gives to wells on salt dome flanks. In the past, special



consideration for salt domes and salt dome flanks has become almost standard procedure.

One operator, admitting that justification of special allowables for salt dome areas on engineering grounds might be difficult, suggested that the removal of this valuable incentive might halt the drilling near the salt dome flanks. In such a case, conservation would be adversely affected.

Basic purpose of the Texas prorationing system is for the conservation of oil resources and the prevention of waste.

The problem of changing the proration of secondary recovery projects, however, will probably not be completely aired in this series of hearings, as there are few or no floods and a very small number of gas injection projects in District 3. Probably the most important question likely to arise from now until May 23, is the application of shutdown days as applied to wells on the flanks of piercement-type salt domes. Exemptions originally were granted to wells on the tops of domes and were later extended to flank producers as they appeared. These wells usually have a very high water-oil ratio, and are virtually all of a wildcat nature, operators say.

Of the total Texas production, the exempt areas turn out about 987,000 bbl daily. It is estimated that one-half of this amount comes from marginal wells, whose production the Railroad Commission has indicated it will not curtail.

The Commission has defined strippers, or marginal wells, generally as those that cannot producer allowables and must oil artificially. These have been allowed to produce on every day of the month. The maximum allowables are based on depths. From 1000 to 2000 ft the allowable is 10 bbl; from 2000 to 4000 ft, 20 bbl; from 4000 to 6000 ft, 25 bbl; from 6000 to 8000 ft, 30 bbl, and from 8000 ft down, 35 bbl.

Another group of wells in the exempt classification are those of the county regular fields. These fields were created as a catch-all for scattered and insignificant wells. Although the county regular fields are comprised of small wells, in many cases the production aggregates to a very significant total, particularly in counties in Districts 9 and 7B.

To alter the status of the county regular fields would be to establish literally thousands of new fields of comparatively little value. Realizing this, the Commission is expected to pass over this category lightly.

General Ernest O. Thompson, senior member of the Railroad Commission, said the hearings will "resemble" proceedings to establish most efficient producing rates and give the operators a new opportunity to justify existing allowables.

In choosing District 3 to lead the review, the Commission picked the area which produces the most unchecked oil flow. This district, which embraces the southeastern part of the state, produces 148,000 bbl daily from shutdown-free fields. The session, as currently scheduled, will continue each Wednesday until all fields in that area have been reviewed, probably culminating May 23.

Hearings on other districts would presumably follow the same pattern in the descending order of total exempt fields. On this basis, a review of District 4, which has 77 fields free from shutdown days, would follow. If probes into all such fields are made, the session might well extend into mid-1957.

No decision into the advisability of continuing these hearings has been made, nor has any thought been expressed as to how the Commission will act on the hearings.

It has been urged by some producers that adoption of any general policies be held until testimony on all areas is in. Operators pointed out numerous pressure maintenance and waterflood projects that are now underway or are planned for immediate construction would not be economically feasible if allowables were changed.

Of the first 10 fields heard by the state examiners in Austin, most of them were exempt because of high salt water content or extreme sanding problems.

Alta Loma field, the first of the fields taken before the examiners, for example, is reported to produce oil with a 96 per cent water content with a 9000 psi flow pressure. This field was brought in last year.

Old Batson and New Batson pools are highly faulted and are noted with erratic field characteristics. New Batson field has 42 wells with a combined daily allowable of 1945 bbl. Old Batson has 162 wells which produce a total of only 837 bbl daily. These were the largest fields to be discussed February 1.

Old Batson was discovered in 1903, and like many of the older fields, original reasons for granting exemptions have been forgotten.

The little Brenham field is made up of several landowner-operated one and two-barrel wells being produced from an 18-in. sand at a depth of about 200 ft. Gravity of oil from Brenham is 14 deg. Nearly any one of these characteristics alone is sufficient ground for exemption.

Other fields heard were Arriola, Bammel, North Bancroft, North Beech, Big Creek, and Big Hill.

These fields include wells with many of the reasons held to be sufficient for granting the exempt status. These include sanding, watering, and log gravity problems; certain marginal wells, piercement type salt domes; old fields where "last attempts" for oil production are being made, as well as one field whose allowable has been set by the state of Louisiana, by virtue of its position on a state line.

In deciding on the status of a Texas field, the Commission operates on the basic attitude that oil conservation and prevention of waste must prevail all other thinking, policies or rulings. It is safe to say that most of the fields will retain the exempt status already granted, as field situations have changed in relatively few cases. * *

"Here comes that Boll-Weevil with the wire-rope now!"

LANE-WELLS TODAY!

PUBLISHED FOR THE BUSY OIL MAN BY LANE-WELLS CO. — ONE OF THE DRESSER INDUSTRIES

New L-W Skyhook Speeds Thru-Tubing Jobs

Through-tubing perforating and logging operations made eminently practical by Lane-Wells slim-hole equipment, now get a time—and trouble-saving assist from a highly portable sky hook which is now available in certain areas. This new Lane-Wells development takes the form of a vest pocket mobile mast that powers its own way into working position in a matter of minutes.

The big advantages of the so-called permanent-type well completions stem from the fact that logging and perforating operations (with Lane-Wells on the job, of course) can be carried on through tubing without the need of an expensive drilling or production-type rig and drawworks. Tools utilized in this service go through lubricators as long as 35 feet and against pressures as high as 3000 psi.

Previously, in the absence of a derrick, gin poles provided the means of supporting the lubricator over the well. Erection of gin pole and lubricator on a Christmas tree required a considerable amount of deft manipulation, several guy wires, and some hazard. The new mobile mast can be positioned by practically any car or truck, and one man at the controls can erect it in working position in 15 minutes.

Here are some more facts about the new mobile mast which should interest operators contemplating remedial or recompletion work through tubing:

1. The rig will support a straight-down pull of 11,000 pounds at a height of 30 feet.
2. The rig takes all columnar load off the lubricator.
3. No guide lines are required.
4. The motor used to raise and lower the mast can be used to raise and lower the lubricator and tools.
5. The gross weight of the complete unit is approximately 2700 lbs.
6. A five-horsepower gasoline engine, with spark-proof exhaust and insulated spark plugs, supplies the power.
7. Wheels do not support derrick load. These are automatically raised as the mast support is grounded and jacknifed.

For more details about this and other aspects of Lane-Wells through-tubing service, check E1 on the attached card.

Want More Information?

More information on items here will be sent to you gladly on request. A code number appears at the end of each article. For additional information about that item circle that code number on the reply card at the bottom of page 3. Just mail the card — we'll pay the postage.

EVER MEET AN "E" ZONE

or

How to Win Friends and Influence Formations

Omitting certain descriptive adjectives, some geologists call it a heavily cemented sand. But certain widening circles of production men call it an "E" zone.

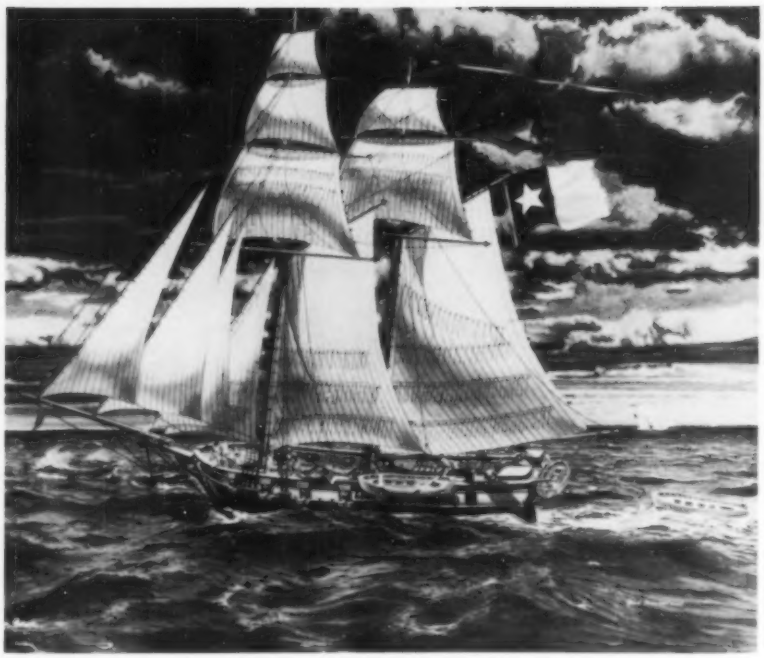
It's all very flattering. "E" zones are those potentially productive horizons which will respond to nothing short of perforating by the mighty Lane-Wells "E" Gun. This bullet perforator can put a hole through heavy casing, cement, and way, way out into the formation to create a drainage area unequaled by any other type of gun perforation. "E" Gun perforations give more than penetration; they create radial shattering — perforations on perforations, as it were—which multiply the chances of payoff production.

As a result of the "E" Gun's performance, operators in many areas are beginning to take another look at certain zones which have not produced according to expectations. In many such zones, the "E" Gun has made the difference between profit and loss on the whole operation.

Lane-Wells engineers can supply you with lots of detailed technical data on why the "E" Gun performs in such a spectacular manner. Briefly, it has to do with bullet design, powder charge, and the use of a solid bar stock gun of maximum strength. But you can get all this information by checking the right number and mailing the attached postal card. You will also find out that the shooting of this gun is as controllable as the keys of a piano. Each shot being individually fireable allows the operator a tremendous range of shot spacing — from 50 shots to the foot, to one shot in 50 feet.

Altogether these items add up to make one big shot that really produces — literally and figuratively. Check E2 on the attached card to bring you the low down on this high-up performer.

You, too, can win friends with "E's"!



A Ship of the Texas Navy!

This tops'l schooner, circa 1836-1843, aided the cause of the Lone Star Republic by harassing enemy supply vessels. Artist Fred Freeman rendered this painting from a model in the U.S. Coast Guard Academy. The photograph of the painting was supplied through the courtesy of the Scovill Manufacturing Co. of Waterbury, Conn.

ABSTRACTS — Current and Pertinent

HOW TO FIND OIL IN DRY HOLES Sometimes, that is. Atlantic Refining Co. has come up with a method of correlating water resistivity, formation factor, and electrical logs to indicate unsuspected oil possibilities in abandoned holes. E3

PETROLEUM GEOLOGY MADE EASY For the casual looker on. The American Museum of Natural History's Hall of Oil Geology in New York gives the whole picture of how oil is created, searched for, discovered, and produced. Realistic diorama models, and maps are used. E4

THROUGH TUBING OPERATIONS PAY OFF — BIG! Gulf chalks up a net saving of $171,087 in Louisiana through the use of permanent-type well completions. E5

DOLLAR SIGN SELLS CORROSION CONTROL TO MANAGEMENT. Technical data are fine, but results in dollars and cents wield the most influence with the top brass. Produce these and you are on your way. E6

SMALLEST ATOM SMASHER AIDS OIL SEARCH — Positive identification and location of oilbearing formations by Radioactivity Well Logging has been advanced by the development of a high energy source in the laboratories of Well Surveys, Inc. E7

HOW POROUS MY SANDS AND SHALY SANDS? Porosity in these formations may now be evaluated by Neutron and Gamma Ray Logs to an accuracy within practical requirements. E8

ANOTHER LANE-WELLS PLUS: 21-24% ADDED PENETRATION

Here's another plus that really pays off — bullet penetration increased by better than 20%! The how and why pays high tribute to the men who have to do with designing and creating Lane-Wells powder charges.

Ballistically, the story boils down to the following: Merely increasing the charge of high-performance powder would not solve the problem of gaining deeper penetration. More powder would mean higher peak pressures, pressures exceeding the boundaries established by safe operating procedures. So, the Lane-Wells staff produced an entirely new kind of powder, one which at no time creates excessive pressure, but one which maintains that pressure over a relatively long period of time. This is the new #7. It sort of gives the bullet a poosh way, way out there.

Tests by a major oil company confirm the story. Three bullets each were fired by the powerful #3 and the new #7 powders into targets made of casing steel and cement. The only difference between the targets was that the steel of the #7 target had higher tensile strength! Bullet penetration for the # 3 averaged 6.22". That for the #7 averaged 7.80". 'Nuff said. But if you really want to know more, check E9 on the attached card.

Do-It-Yourself Straddle Packer Proves Useful Breakdown Tool

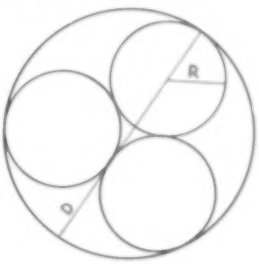
One of the neatest tricks in down-hole procedure concerns the use of a straddle packer to confine breakdown fluids to a specific set of perforations. What makes this particular packer application so attractive to the cost-conscious operator is that it involves the use of two regular-purpose Lane-Wells packers. No expensive special-purpose tools or complicated procedures are involved.

In fact, any reasonably competent drilling crew can put the straddle assembly together to suit the job at hand without leaving the shadow of the derrick. The tool pusher could just about do it all by himself, if he were so inclined. It consists of a BOCU packer and a Hydraulic Hold Down Tool on top and a BOC packer below. The two packers are separated by a length of perforated tubular goods depending upon the zone to be isolated. The combination, run on tubing or drill pipe, can be set and reset without ever coming out of the hole. It will handle any pressures safe for the casing from within, above, or below. Once the job is finished the assembly can be taken apart in a jiffy.

You can get formation breakdown work done with much more expensive equipment than the Lane-Wells Straddle Assembly. But if your boss is concerned about costs of such operations, you had better check E10 on the enclosed card.

Super Brain Breaker

Given three equal tangential circles circumscribed by a larger outer circle as in the diagram. Given the smaller circle radius R=15", determine the diameter, D, of the larger circle. This is not too super, provided you follow the right procedure.



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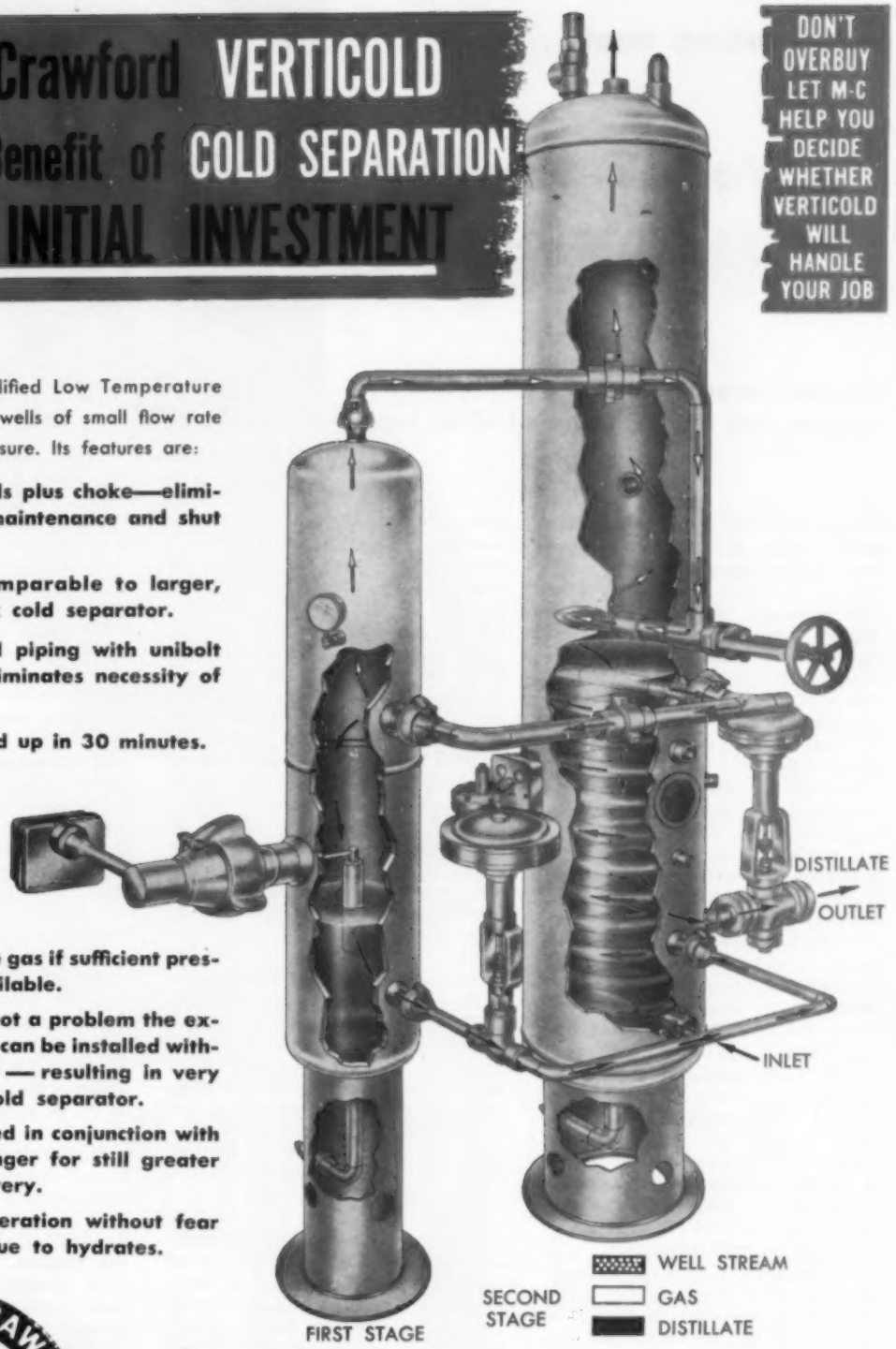

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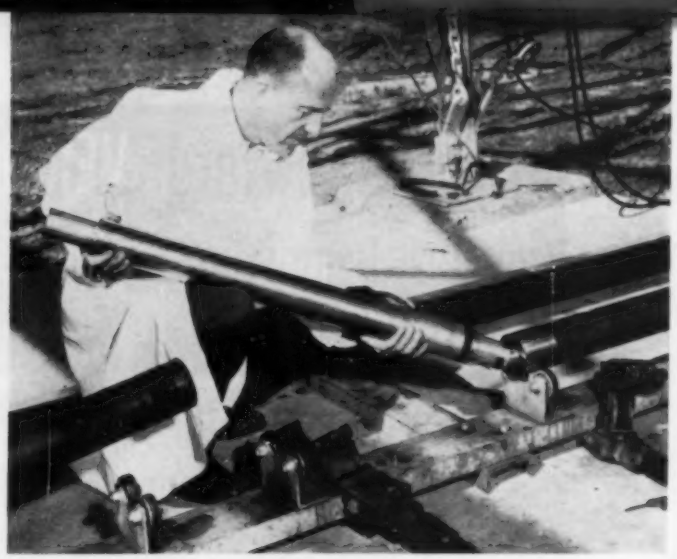

WORLD'S SMALLEST ATOM SMASHER is assembled at test well site by James A. Cooley of Well Surveys, Inc.

RADIOACTIVITY well logging was pushed several strides closer to positive identification and location of oil-bearing formations recently by the first successful test of the world's smallest "atom smasher" by Well Surveys, Inc., an affiliate of Lane-Wells Company. Perfection of this miniature high energy source is one step in the application of atomic energy to oil field problems begun by the company nearly 20 years ago.

This unique neutron generator, incorporated in a standard 3⅝ in. well logging assembly, is itself only 3 in. in diameter and 47 in. long, yet has been developed to provide the most intense beam of neutrons ever used in a well. The device actually is a miniature version of a Van de Graaff paritcle accelerator, a large radiation-generating machine long used for physics research, cancer therapy and more recently for chemical processing and sterilization.

The "baby" accelerator was developed and constructed for Well Surveys by High Voltage Engineering Corporation, Cambridge, Massachusetts, world's leading designers and builder of particle accelerators. The complex instrumentation used with the neutron source has been developed by Well Surveys' scientists and engineers.

The miniature Van de Graaff generates electrical potentials up to 200,000 volts which are used to produce a stream of atomic particles called deuterons. These particles, actually the nuclei of heavy hydrogen atoms, are fired into a target of tritium (super heavy hydrogen). The collisions of deuterons with tritium atoms produces an intense yield of neutrons.

These neutrons, travelling at extremely high speeds penetrate the earth's formation surrounding a borehole and cause various nuclear reactions in the material encountered. These reactions, in turn, yield atomic particles and rays which can be identified and measured by sensitive radiation detection equipment which accompanies the accelerator down the hole.

The resulting information, transmitted to the surface and recorded, when correlated with the results of neutron radiation research performed with the large half-million-volt accelerator in Well Survey's laboratories, will be extremely useful in the identification and evaluation of formation constituants.

Further development of this unique type of equipment represents a scientific approach to the eventual positive identification and location of oil at great depths, in new or existing boreholes.

Successful completion of the device is the culmination of many years' intensive effort. "While Well Surveys had pioneered the uses of sub-nuclear particles and radiation in oil-exploration, we fully recognized the difficulties involved in obtaining a working source of neutrons suitable for the most promising techniques," recalls Dr. John H. Buck, vice president and technical director of Well Surveys, Inc.

"After all, the smallest Van de Graaff then built was a 500,000-v unit 4 ft in diameter and 6 ft long, yet we wanted a high flux of fast neutrons from a unit small enough to penetrate any drill hole. Beyond that, the device had to draw very little electrical power, withstand temperatures up to 300 F and external pressures up to 20,000 psi. That was quite an order."

"After exhaustive study of the problems involved and extensive discussion with High Voltage scientists, we decided to utilize their unique technical experience in a joint effort toward this goal.

"Concurrently," Dr. Buck continued, "we installed a Van de Graaff machine in our research laboratories to assist us in the refinement of detection apparatus and in the interpretation of logging data."

Dr. Buck explained that a basic initial decision made by the two companies was that their efforts would be aimed directly at the ultimate goal of perfecting equipment small enough and reliable enough to meet well-logging demands in the oil industry, as opposed to a step-by-step development.

"We knew that approach would take longer in the earlier stages, but felt that time would be saved in the long run. Now we're glad we chose it," Dr. Buck asserted.

Preliminary tests have already been run in a test well at Tulsa. An intensive test program for both the neutron source and accompanying instrumentation will be accelerated through the coming months, according to Dr. Buck. "Naturally, every effort will be made by both companies to hasten the availability of this advanced logging method to the oil industry generally," he concluded.

High Voltage Engineering's Van de Graaff accelerators are already familiar sights in the petroleum industry, where they are being used widely both for fundamental and for chemical processing research. Such leaders as Shell, Gulf, Socony, Magnolia, and Humble have purchased multi-million volt machines for these applications.

Well Surveys, Inc., pioneered gamma ray and neutron logging as early as 1938 and shortly thereafter licensed Lane-Wells Company to introduce this new service commercially. Since that time, the two companies have collaborated on the continuous improvement of equipment and techniques, including dual-logging, small diameter instrumentation for permanent type well completions and collar logging. ★ ★ ★

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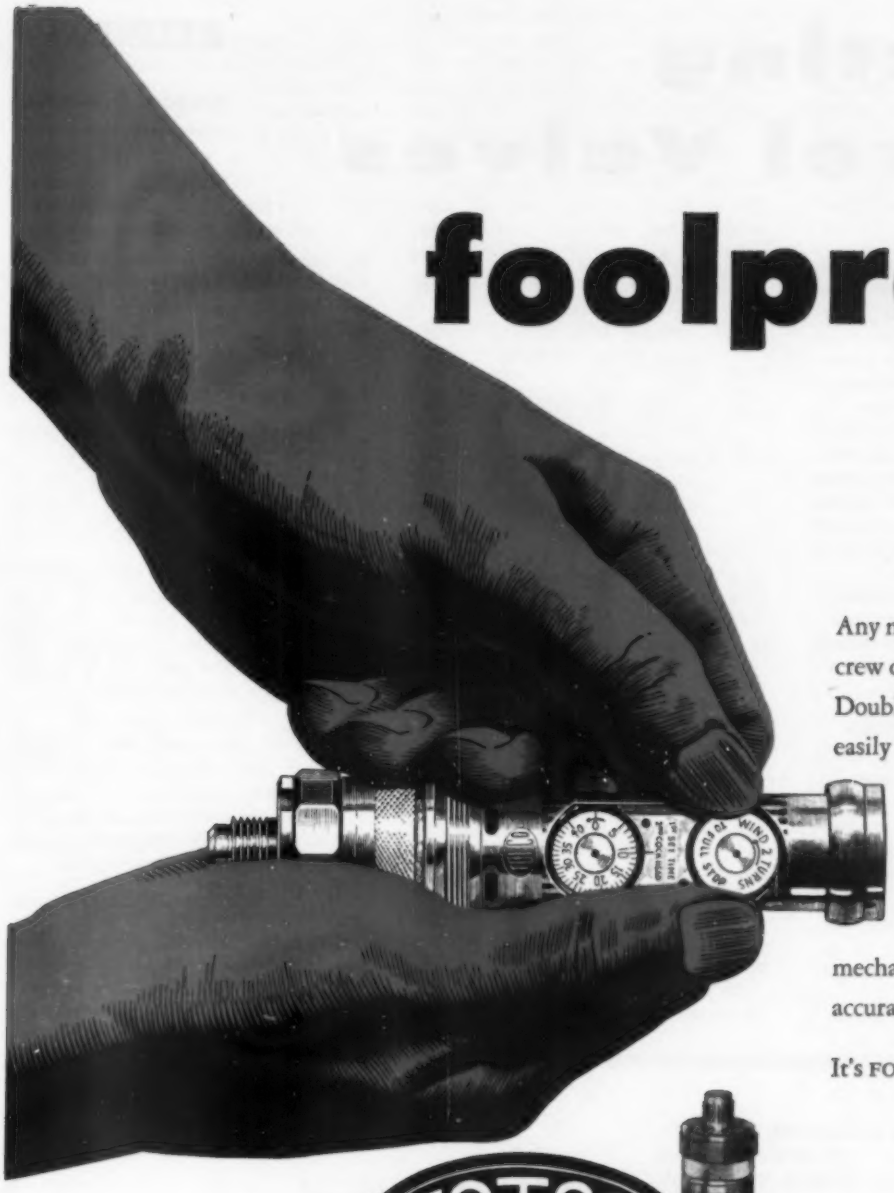

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P 542.3

EXCLUSIVE

Selecting Control Valves

Herbert S. Kindler
Black, Sivalls & Bryson, Inc.
Oklahoma City, Okla

WITH the increasing use of unattended installations and remote control equipment in the field, the proper selection of control valves and other units has become increasingly important. This is a step-by-step outline of the conditions and calculations required to select control valves for a wide number of applications. It is intended to aid engineers in designing control systems faster and with greater accuracy. Also, it is hoped that this will provide a basis for future standardization programs.

Material supplements information provided by control valve manufacturers and includes pressure drop considerations, angle valve capacity, and the selection of valve features.

Pressure Drop Considerations

Before the valve liquid-flow coefficient (Cv) can be obtained from the manufacturer's sizing manual, the pressure drop available to the valve must be determined. The following formula is used to determine valve pressure drop:

$$\Delta P_v = P_s - P_t - \Delta P_e - \Delta P_L - H$$

Where

ΔP_v = pressure drop available to control valve, psi.

P_s = pressure at source (pump, vessel, line, etc.) psia.

P_t = pressure at terminal (sump, vessel, line, etc.), psia.

ΔP_e = pressure loss through equipment (filter, exchanger, etc.), psi.

ΔP_L = pressure loss through line and fittings, psi.

H = Hydrostatic head (vertical distance in feet between source and terminal × liquid specific gravity × .4335), psi.

Note that if the density downstream of the control valve is appreciably different from the upstream density, "H" is computed as follows:

$$H = [A\ (ft) \times \text{Density A} + B\ (ft) \times \text{Density}_B]\ [.4335],\ psi$$

Although valve pressure drop has been determined, it should be checked against **system** pressure drop. It is obvious that if all the pressure drop was distributed across the exchanger, line, and fittings, and no pressure drop was available to the valve, the valve opening could have no effect on the flow. If only a very small portion of the available pressure drop was allotted to the valve, it would have to change position considerably to affect the rate of flow.

In order to establish a reasonable pressure drop for the valve, the following rule-of-thumb is offered. The formula is set up to insure that the system friction, either due to increased capacity or to fouling fluids, will not take control away from the valve.

$$\frac{\Delta P_v \times 100}{\Delta P_v + \Delta P_L + \Delta P_e} \geqslant 33 \text{ per cent}$$

If pressure drop conditions satisfy the above equation, the valve will have satisfactory control over the system.

The following practical example shown in Fig. 1 illustrates the use of these formulas.

The line pressure loss was calculated by conventional methods to be 2 psi and the exchanger pressure loss was found to be 3 psi. Substituting this data in the valve pressure drop formula, ΔP_v is found as follows:

$$\Delta P_v = P_s - P_t - \Delta P_L - \Delta P_e - H$$

$$\Delta P_v = 440 \text{ psia} - 422 \text{ psia} - 2 \text{ psi} - 3 \text{ psi} - (36 \text{ ft} \times .57 \times .4335)$$

$$\Delta P_v = \mathbf{4\ psi}$$

Testing the valve pressure drop obtained in the above example against the controllability formula yields:

$$\frac{4 \text{ psi} \times 100}{4 \text{ psi} + 2 \text{ psi} + 3 \text{ psi}} = 44.5 \text{ per cent}$$

Since 44.5 per cent is greater than the required 33 per cent, the valve pressure drop of 4 psi is satisfactory for use in determining C_v from a valve

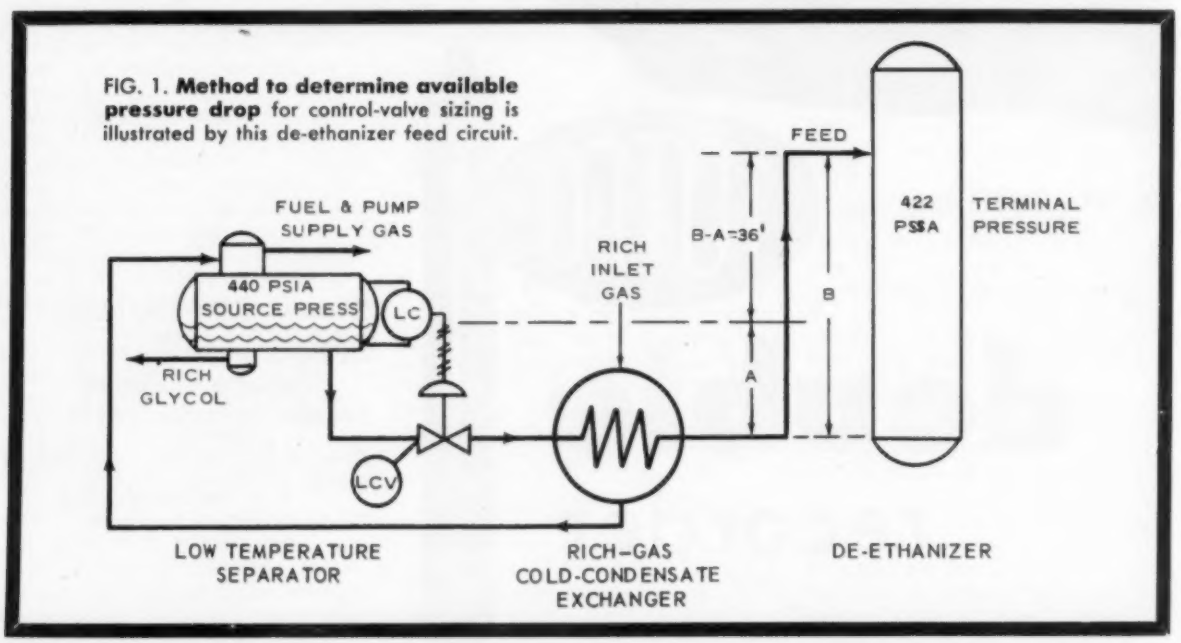

FIG. 1. **Method to determine available pressure drop** for control-valve sizing is illustrated by this de-ethanizer feed circuit.

sizing manual.

Note that in this discussion of pressure drop considerations, all comments also apply to steam and gas as the flowing medium except, of course, hydrostatic head is neglected. In the above example, no flashing of the fluid is assumed.

Coefficient C_v. C_v is defined as the liquid-flow coefficient of a valve at a specified lift, and is numerically equal to the number of gallons per minute of water at 1.0 sp gr that a valve passes with a pressure drop of 1 psi. Sizing manuals have tabulated C_v vs inner valve travel for variously shaped inner valves. In determining valve size, C_v's should be obtained for limiting design conditions. That is, a value of C_v for the minimum expected flow at the maximum possible pressure drop conditions, and another value for maximum expected flow at the minimum pressure drop.

A rough rule is to select the inner valve size and type so that the maximum C_v occurs at 80 to 90 per cent of total valve travel, and the minimum C_v occurs at 20 to 30 per cent of total valve travel. Fig. 2 illustrates the typical characteristics of four inner-valve types for a ¾-in. single-port valve.

This figure indicates that the percentage "V" has less capacity than the parabolic. Quick-opening plugs of comparable lift give maximum capacity. (In the above plot, while the rated travel of the percentage "V" and parabolic is ¾ in., the travel of the quick-open inner valve is only ⅜-in.)

Viscous Fluids. In the definition of C_v, no allowance is made for viscosity since the test medium is water. The control-valve capacity varies, however, as a function of the Reynolds number. Viscosity correction factors previously presented in various published papers are plotted against Reynolds number in Fig. 3.

Some numerical conversions have been made to the original data in order to express the viscosity correction factor in common terms. Data obtained from the limited, viscous flow tests conducted in BS & B's research and development laboratory substantiates, in general, these published data. Where viscous effect is a consideration, such as heavy fuel oil, the correction procedure indicated in Fig. 3 is recommended.

Capacity of Angle Valves. With flow in the direction tending to close the valve, maximum capacity expected for globe valves may not be obtainable. One theory is that the liquid stream does not fill the nozzle fully, leaving a vapor space. Since vapors are subject to critical flow (i.e., no increase in flow accompanies an increase in pressure drop beyond approximately one-half the absolute upstream pressure), vapors prevent maximum liquid flow from being realized. From data obtained to date, it appears that to properly size these valves the pressure drop should be limited as follows:

Inner Valve Size (Inches)	Maximum Allowable Pressure Drop Per Cent of Inlet Absolute Pressure
1½	20 per cent
1¼	23 per cent
1	25 per cent
¾	30 per cent
⅝	36 per cent
½	40 per cent
⅜ and smaller	50 per cent

Flashing Liquids. An accurate, practical method for sizing valves for a flashing liquid service has not been generally accepted by either the industry or the professional societies. However, the influence of flashing on valve size is appreciable and often requires a size or two larger than is figured on a liquid basis.

One approximation method is a heat balance around the valve to calculate the amount of vaporization assuming no radiation losses. The C_v for the liquid and the C_v for the vapor are then determined and added together to size the valve.

Data are available for approximating valves for flashing hydrocarbon service. Precise methods of valve sizing for flashing water and flashing ammonia, based on extensive laboratory tests at Black, Sivalls & Bryson, Inc., are available. Presentation of the complex techniques used is beyond the scope of this article.

Inner Valve Size vs. Body Size. An uneconomical practice sometimes followed in selecting valve body size is to match line size and then reduce the inner port size. The cost of two reducers is almost always less than the increased cost of the oversized valve body. The general recommendation is to maintain the same inner valve size and nominal valve body size for all valves larger than ¾-in. Note that reduced trim is available for the larger sized valves but is normally not economical except under special circumstances. One instance where reduced trim might be justified is where a system expects to operate at one flow rate for a period of time and then increase its capacity. In this case, the valve body can be reused with a larger inner valve.

Maximum Pressure Differential for Single-Seated Valves. Low-lift valves can be used with a larger pressure differential across the valve than high-lift valves using equivalent springs and diaphragms. A low-lift plug should be considered where pressure differential

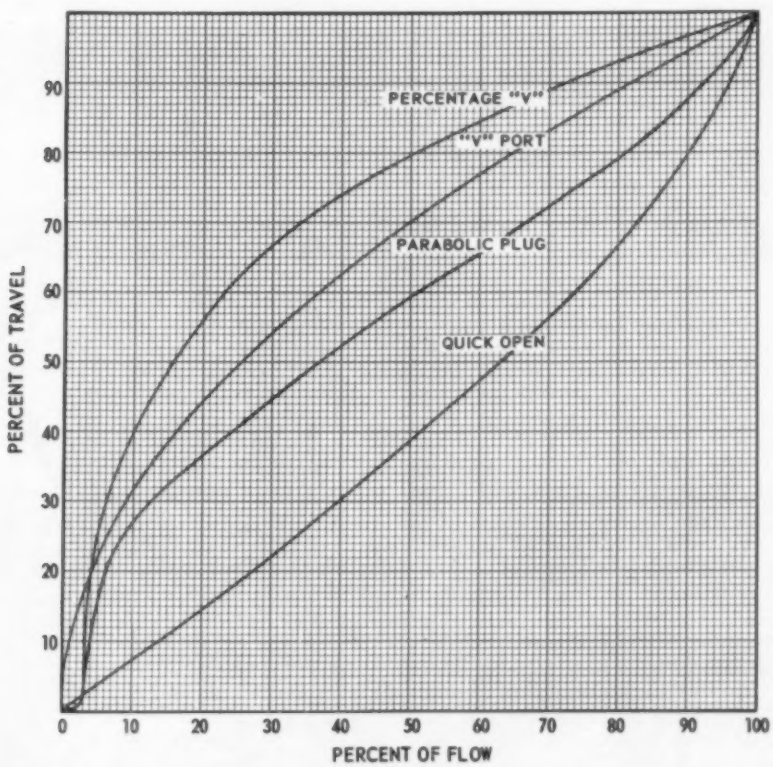

FIG. 2. **Inner flow valve characteristics** shown above are typical for the four types designated. Note that quick-opening plugs of comparable lift give maximum capacity.

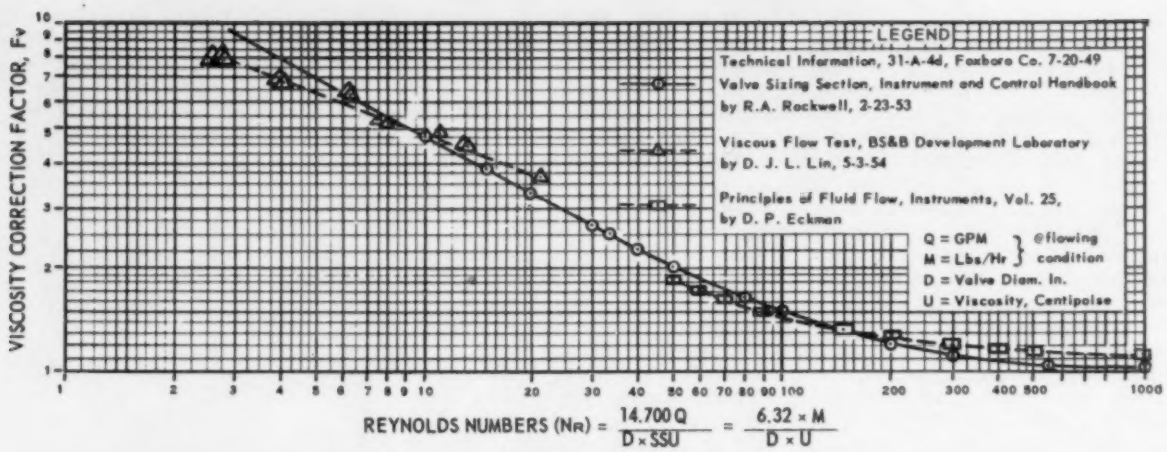
VISCOSITY CORRECTION FACTOR, Fv
LEGEND
Technical Information, 31-A-4d, Foxboro Co. 7-20-49
Valve Sizing Section, Instrument and Control Handbook by R.A. Rockwell, 2-23-53
Viscous Flow Test, BS&B Development Laboratory by D. J. L. Lin, 5-3-54
Principles of Fluid Flow, Instruments, Vol. 25, by D. P. Eckman
Q = GPM
M = Lbs/Hr
@flowing condition
D = Valve Diam. In.
U = Viscosity, Centipoise
REYNOLDS NUMBERS (NR) = 14,700 Q / D × SSU = 6.32 × M / D × U

FIG. 3. **Viscosity correction factors** plotted against Reynolds Number. The true capacity of a control valve can be computed from this chart if the Reynolds Number corresponding to the fluid viscosity is known.

Sizing Procedure

1. Compute Cv neglecting fluid viscosity by $Cv = Q\sqrt{\frac{G}{\Delta P}}$
2. Find valve size based on computed Cv (Step 1) from manufacturer's sizing manual
3. Compute Reynolds Number for specified fluid viscosity and valve diameter determined in Step 2.
4. From this graph, find viscosity correction factor (Fv) based on the computed Reynolds Number.
5. The required $Cv' = Cv \times Fv$.
6. If the required Cv' is greater than the maximum rated Cv in the sizing manual, repeat Steps 2 to 6 for one size larger valve until the required Cv' is less than the maximum rated Cv listed in Cv ratings of the manufacturer's sizing manual.

is a governing factor.

Selecting Valve Features

Valve Action on Air Failure. In selecting valve action, first consider the safety factor; if safety is not involved, then consider the process requirements in deciding whether the valve should fail open or closed. For example, a valve operating on cooling water to a

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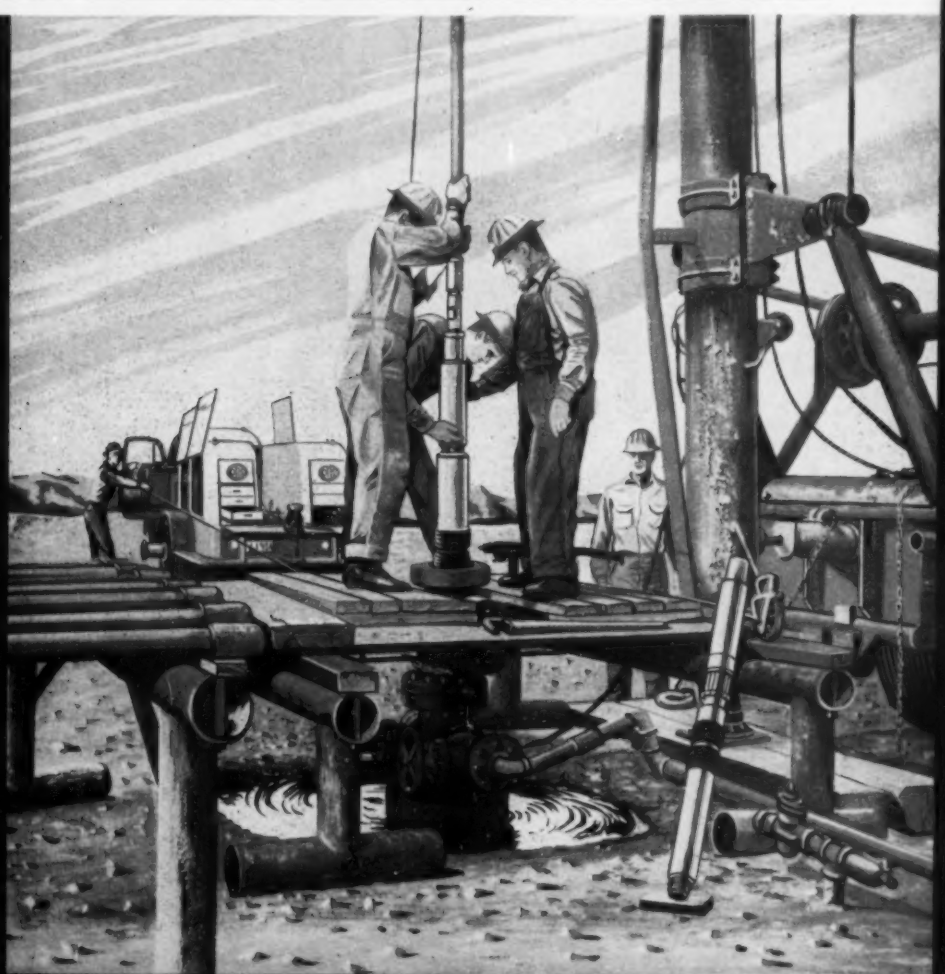

compressor should fail open to protect the equipment from overheating.

Topworks Action. The topworks action is dictated by the controller action and the valve action on air failure. For example, a direct-acting (air-to-close) controller signal sent to a valve that closes on air failure, requires a reverse-acting topworks.

Hardened Trim. Trim is generally defined as consisting of the inner valve, seat ring, lower stem, and that portion of the stuffing box in contact with the flowing fluid. A rule-of-thumb is to specify hardened trim for applications where the valve pressure drop exceeds 150 psi to minimize erosion. One hundred and fifty psi is only a guide since this figure can be considerably exceeded for clean gases, whereas steam tends to channel grooves into the heat ring when the valve plug operates near its seat.

Tight Shut-Off. Double-seated valves of 1-in. and larger will leak approximately ½ of 1 per cent of the valve capacity. If this leakage is excessive, consider using a single-seated valve. Leakage of a single-seated valve can be approximated as not exceeding .05 per cent of its capacity.

Finned Extensions. Radiation fins on Teflon packed valves are normally required when the fluid temperature exceeds 400 F and on graphitized asbestos packing where the temperature exceeds 450 F. Fins should also be considered where the combination of fluid and ambient temperatures are likely to cause frost on the valve stem.

Valve Positioners. A pneumatic valve positioner applies power to the valve diaphragm whenever a change in position is required. Positioners should be considered where **close control** is desired. For example, do **not** specify positioners for "on-off" applications, such as separator dump valves, or where the valve receives its control from a snap-acting controller. Consider positioners:

a. For all flow-control and high-temperature applications.
b. Where the valve will handle heavy residium, slurries, or other viscous, contaminated, or corrosive fluids.
c. Where the pneumatic controller has a wide proportional band.
d. For split-range valves; for example, where one valve is fully stroked with 3 to 9 psi controller output, and the other valve is fully stroked with a 9 to 15 psi impulse.
e. With Saunders patent valves, pinch valves, and butterfly valves.

Flushing Connection. Where heavy oil, or other mediums that tend to deposit tars or coke are encountered, a pipe connection should be specified to enable effective flushing. This connection also serves as a drain and enables pressure to be relieved from the valve body before its removal from the line.

Bellows Seal. The bellows seal may be specified where stuffing box leakage

The Author

Herbert S. Kindler is an instruments engineer for the oilfield division of Black, Sivalls & Bryson, Inc., Oklahoma City, Oklahoma, and has been working with instrumentation and automation since his graduation from Massachusetts Institute of Technology in mechanical engineering. He has been affiliated with the James P. O'Donnell Company, the Brown Instruments Division of Minneapollis-Honeywell Regulator Company and the Catalytic Construction Company, and then founded his own consulting practice in Philadelphia, Pennsylvania. He is a registered professional engineer in New York. Kindler was instrumental in organizing the Instrument Society of America, Oklahoma City section, of which he is now president.

Easy to Run • Easy to Pull • Positive Lock • Positive Seal • The new Otis "Selective" Collet Packer employs the same principle of a "selective" landing nipple and a locating and pack-off assembly used in Otis sub-surface controls. The tool has four principal parts: A *casing landing nipple;* a *packer body,* which seats in the nipple; a *seal nipple* which lands in the packer, and a *locating and packing assembly* which makes up in the tubing string *(see illustration).* The seal nipple and locating assembly can be run and set together on the tubing in only a half round-trip, or the packer body can be run with wire line tools and the installation completed when tubing is run. Both the packer body and the seal nipple are locked in position with heavy-duty collets and sealed off by sturdy V-type packing. The packer body also has a set of "selective" keys to position the assembly in its specific "selective" landing nipple.

The tool allows the tubing to be raised for circulation, it can be reset in a nipple at another interval, or easily pulled if a drill string, instruments, or other tools must be run in the well. The packer also has special advantages in permanent completions and in crooked or directional holes. Due to the collet locking design, rotation of the tubing is not necessary to set the tool. No slips are used which might damage the casing wall or corrode to a tapered mandrel.

Several of these new Otis Landing Nipple Packers are in successful operation throughout the Gulf Coast and Mid-Continent areas. Your nearest Otis office will be glad to tell you about one in or near your field, describe the packer to you, give you illustrated literature, and discuss with you how this new tool may be adapted to your completion program. There is no obligation, and you will find our field men anxious to help you in any way they can. Call one of these Otis offices:

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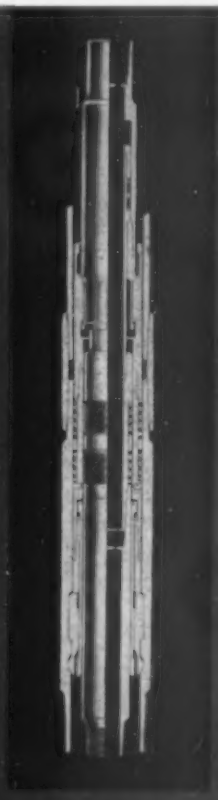

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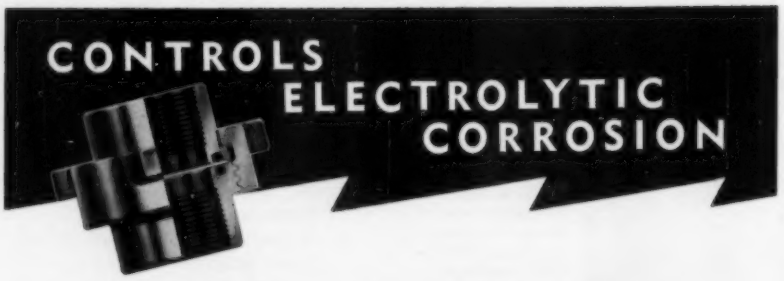

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Acknowledgment

The author thanks A. J. Hanssen, R. Huse, and D. J. L. Lin, of the Climax division for reviewing this article; L. L. Laurence and Dr. E. C. Young, of the oil and gas division for their encouragement, and Black, Sivalls & Bryson, Inc., management for permission to publish this paper. ★ ★ ★

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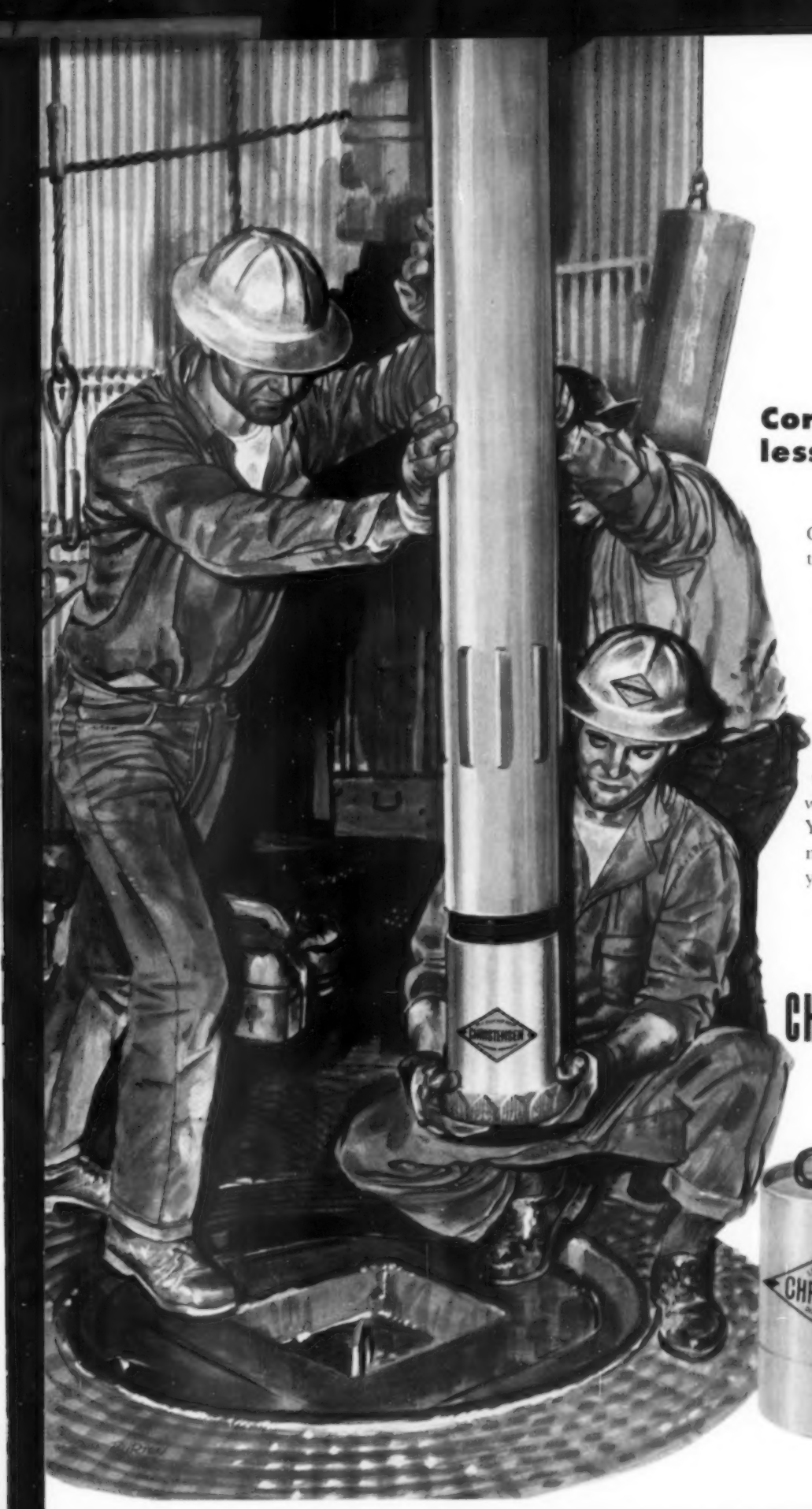

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Sweep Efficiencies of Vertically Fractured Five-Spot Patterns

If only center well were fractured, efficiency would not substantially exceed the unfractured efficiency of 72.3 per cent

Paul B. Crawford,
James M. Pinson*
Jack Simmons**
Bobby L. Landrum
Texas Petroleum Research Committee
A&M College, College Station, Texas

POTENTIOMETRIC model studies have been made of the effect of vertical fractures on the sweep efficiency of the five-spot pattern. All fractures originated at the well and extended out into the reservoir for various distances and orientations. The sweep efficiencies were found to vary from near zero to 73 per cent, depending upon the length and orientation of the fracture. It was found that if only the center well in the five-spot pattern was fractured the sweep efficiency would never exceed the unfractured sweep efficiency of 72.3 per cent by any substantial amount.

If the length of the vertical fracture at the center well were 20 per cent of the well spacing the sweep efficiency may be between 50 and 71 per cent, depending upon the orientation of the fracture. For a fracture length of 50 per cent of the well spacing the sweep efficiency might vary from 18 to 62 per cent. If the center well and a corner well of the five-spot pattern is fractured, it may be possible to increase the sweep efficiency by creating a third fracture at a corner well. The fracturing of a diagonally opposite well may or may not be more effective for this purpose than fracturing an adjacent corner well, depending on the particular existing fractures.

To utilize a vertically fractured well effectively in some instances it may be desirable to use the fractured well as the center well of a five-spot pattern rather than a line drive pattern. It is concluded that when more than one well of a five-spot pattern is fractured, an individual study may be required to achieve maximum oil recovery.

*Present Address—California Co.
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Previous Study Extended

The application of commercial fracturing techniques to reservoirs which may be water flooded or gas cycled has led to considerable speculation on the effect such fractures may have on sweep efficiencies. It has been indicated previously that for the case of the line drive pattern the creation of a vertical fracture may result in an increase or a decrease in sweep efficiency, depending upon the length and orientation of the fracture and the direction of the flooding or cycling program(1). The present study is an expansion of previous work to include the effect of vertical fractures on the sweep efficiencies of the five-spot pattern.

Setting Up the Model

A potentiometric model was used in making this study. A description of this model has been presented previously(2) (3) (4). The five-spot pattern was simulated by a waxed wooden reservoir 20 by 20 in. approximately 1 in. deep filled with a dilute salt solution.

Vertical fractures were simulated by the use of copper strips which were soldered to strips of wire representing the wells in the five-spot pattern. The reservoir depth was uniform which corresponded to a constant permeability-feet product from input to output wells. The model as used herein indicates the results which may be expected if a uniform homogeneous reservoir consisting of an infinite array of the shown patterns were flooded at a mobility ratio of one at steady-state conditions, and the effects of gravity are entirely ignored. These conditions require that considerable caution be exercised in endeavoring to extrapolate the results to field conditions.

Sweep Efficiencies of Five-Spot Patterns

Fig. 1 shows a typical five-spot pattern in which the outer wells, numbers 1 through 4, are unfractured and the center well, number 5, is fractured. The fracture is centered at well 5 and is equal to 21.2 per cent of the well

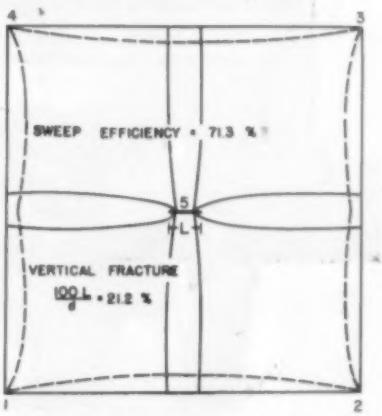

FIG. 1. **Center Well Fractured** only in typical five-spot flood pattern.

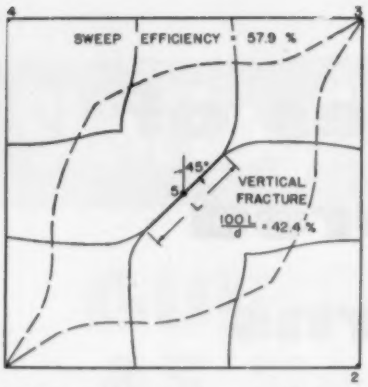

FIG. 2. **When Fracture** is 42.4 per cent of well spacing, this is the swept area and percentage efficiency.

spacing in length. That is $\frac{100L}{d}$ is equal to 21.2 per cent, corresponding to 140 ft in a 10-acre spacing. The dashed lines in all figures show the shape of the oil-water interface at break-through where the center well is the input well; the solid lines represent the shape of the oil-water interface when the outer (or corner) wells are the input wells. The sweep efficiency was found to be 71.3 per cent for both conditions. It was found that in all cases studied that the sweep efficiency was the same whether the center well was the input well or all the corner wells were the input wells.

It will be noted that this value is near the sweep efficiency of 72.3 per cent which would be expected if no fracture were present. It is desired to point out that the location at which the water first breaks through along the vertical fracture does not occur at the tip of the fracture, but at a point intermediate between the tip of the fracture and the producing well.

Fig. 2 shows the swept area of a vertically fractured five-spot pattern in which a vertical fracture of length equal to 42.4 per cent of the well spacing is present at the center well. The vertical fracture is shown to be oriented 45 deg from the "y" axis, the reference axis used in this study. A sweep efficiency of 57.9 per cent was obtained. It will be noted that breakthrough is expected to occur simultaneously at wells one and three and that at this particular time the water will have advanced only about 60 per cent of the distance between wells No. 5 and No. 2 or No. 5 and No. 4. Wells No. 1, No. 2, No. 3 and No. 4 were operated at the same voltage in the model which corresponds to operating the wells at the same pressure in the field.

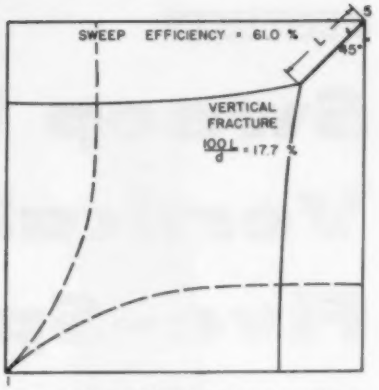

FIG. 4. **One Quadrant** of vertically fractured five-spot pattern showing sweep efficiencies.

Table 1 shows the fluid flux at all wells for various conditions based on a flux of 100 at well No. 5, illustrated in Fig. 2. The corresponding rates of production (or injection) at wells No. 1, 2, 3, and 4 will be 26.3, 23.7, 26.3 and 23.7, respectively. Although the vertical fracture at well No. 5 has little effect on the injection rates of wells No. 1 and No. 3 it does serve to reduce the sweep efficiency from 72.3 to 57.9 per cent.

Fig. 3 is a graph of the effect of ver-

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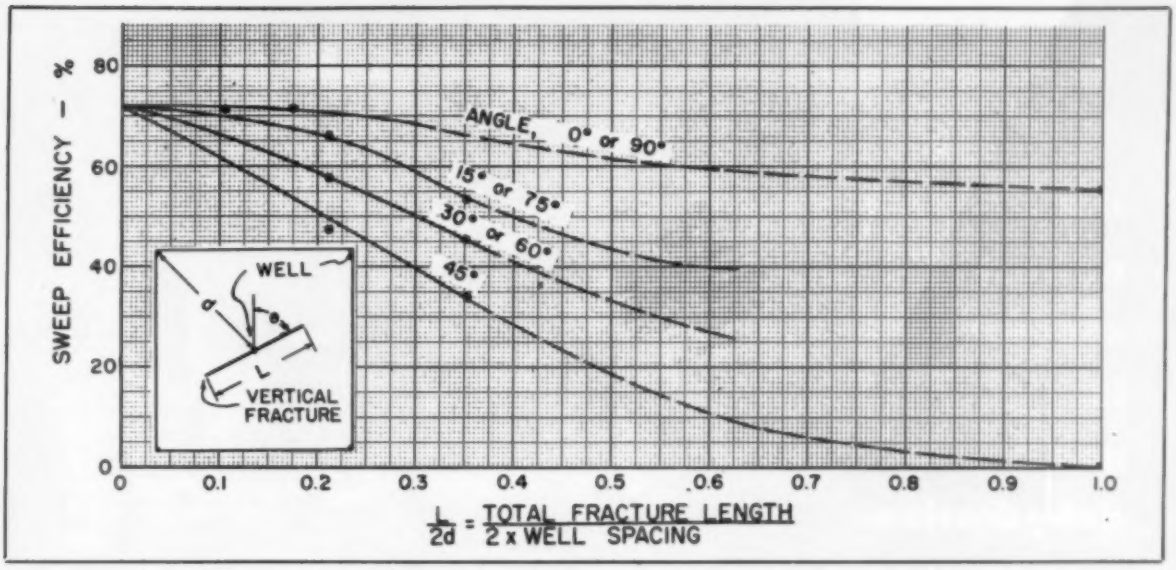

FIG. 3. **Effect of Vertical Fracture Length** and orientation of five-spot sweep efficiencies.

tical fracture length and orientation on sweep efficiencies of the five-spot pattern where only the center well is fractured. The abscissa shows the total fracture length divided by two times the well spacing; the ordinate shows the sweep efficiency. If the pattern is unfractured a sweep efficiency of 72.3 per cent would be expected. If a vertical fracture exists at the center well and is oriented at either zero or 90 deg from the "y" axis (see insert) a sweep efficiency of from 72 to 70 per cent would be expected for half-fracture lengths up to 25 per cent of the well spacing. If the fracture length were increased indefinitely, however, the sweep efficiency would approach 56 per cent. Similar effects may be noted for other orientation. The most pronounced effect on sweep efficiency

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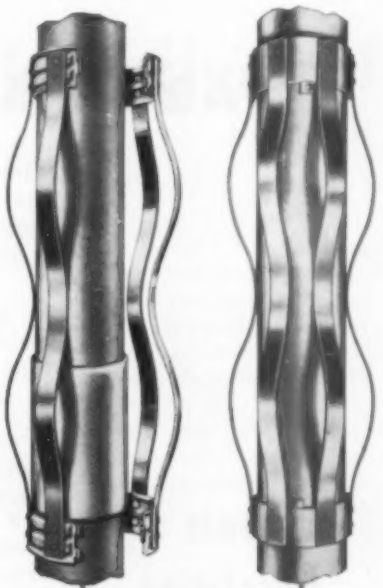

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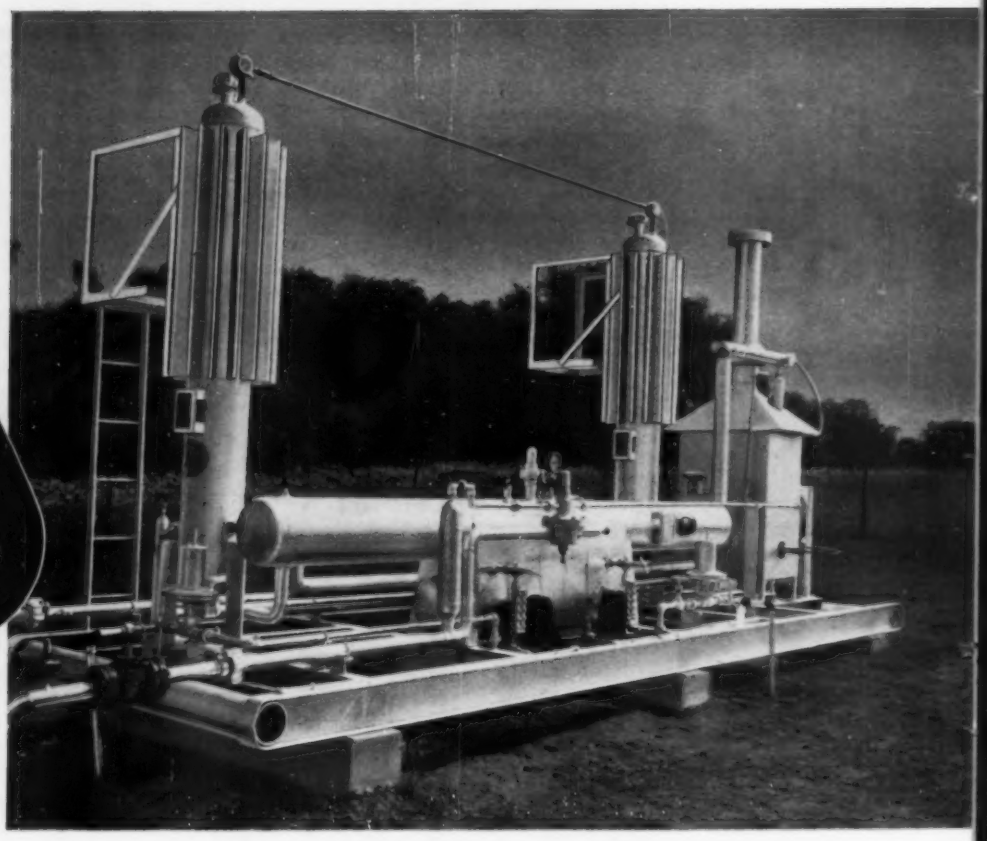

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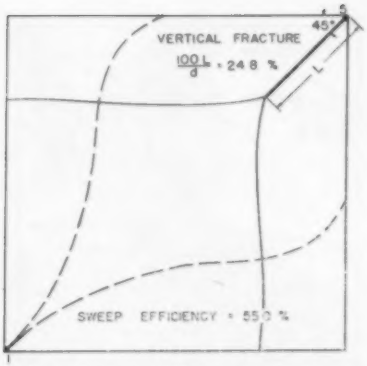

FIG. 5. **Sweep Efficiency** of 55 per cent was observed where vertical fracture was 24.8 per cent of well spacing.

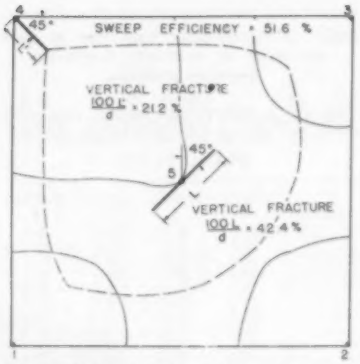

FIG. 6. **Oriented Fractures** between one corner well and center well as indicated show sweep efficiencies of 51.6 per cent.

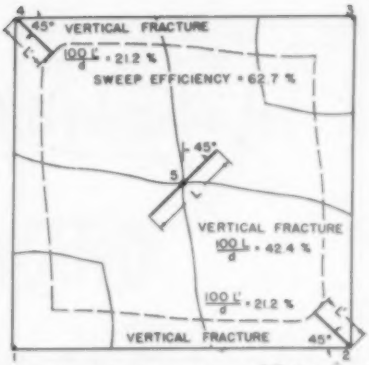

FIG. 7. **Three Fractured Wells** in five-spot pattern as indicated increased sweep efficiency to 62.7 per cent.

was found to occur when the vertical fracture was oriented 45 deg from the "y" axis, or along a diagonal connecting opposite corner wells. For these conditions sweep efficiencies near 50 to 28 per cent may be expected if the half-fracture lengths are between 0.2 to 0.4 of the well spacing respectively. If the half-fracture length equaled the well spacing a sweep efficiency of near zero would be expected.

Fig. 4 shows the swept area of one quadrant of a vertically fractured five-spot pattern. Note that well No. 1 is located in the lower left hand corner as before, while well No. 5, which is the center well of the pattern, is in the upper right hand corner in this figure. The remaining three quadrants are mirror images of the quadrant shown. That is, at well No. 5, four vertical fractures exist and extend 17.4 per cent of the distance toward the opposite corner wells. These fractures, resulting in a cross, originate at well No. 5 and extend directly toward each of the four surrounding wells. For this particular case a sweep efficiency of 61 per cent was observed.

Fig. 5 shows a similar pattern to that of Fig. 4, except that the vertical fracture in this instance was 24.8 per cent of the well spacing. A sweep efficiency of 55 per cent was observed.

Fig. 6 shows the sweep efficiency of a vertically fractured five-spot pattern when well No. 5 possesses a vertical fracture whose length is 42.4 per cent of the well spacing oriented at an angle of 45 deg from the "y" axis. Well No. 4 has a vertical fracture that is 21.2

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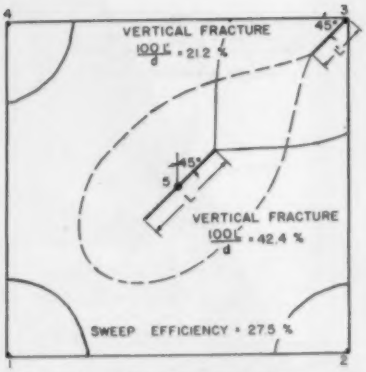

FIG. 8. **In Line Fractures** between center and corner well produce this type of sweep pattern and an efficiency of 21.2 per cent.

Table 1. Steady-state fluid flux at corner wells of vertically fractured five-spot patterns.

Basis
Center Well Fluid Flux = 100
See figures for well locations

FLUID FLUX

Figure No.	Well No. 1	Well No. 2	Well No. 3	Well No. 4
1.....	25.0	25.0	25.0	25.0
2.....	26.3	23.7	26.3	23.7
4.....	25.0	25.0	25.0	25.0
5.....	25.0	25.0	25.0	25.0
6.....	16.9	17.2	16.9	49.0
7.....	19.0	31.0	19.0	31.0
8.....	27.0	21.9	29.2	21.9
9.....	39.6	10.4	39.6	10.4
10.....	33.6	16.4	13.2	36.8
11.....	43.9	10.5	35.1	10.5

per cent of the well spacing, oriented 45 deg as shown. Wells No. 1, 2 and 3 are unfractured. For this particular condition a sweep efficiency of 51.6 per cent was observed. Table 1 indicates that for these conditions the fluid production (or injection) rates at wells 1, 2, 3 and 4 were found to be 16.9, 17.2, 16.9 and 49.0, respectively, on the basis that the rate of injection at well No. 5 was equal to 100. It is to be pointed out that the creation of the vertical fracture at well No. 4 results in a substantial increase in fluid flux at this well.

Fig. 7 shows the swept area of a vertically fractured five-spot pattern in which a vertical fracture that is 42.4 per cent of the well spacing exists at well No. 5. Vertical fractures that are 21.2 per cent of the well spacing exists at wells No. 2 and 4. For these particular conditions a sweep efficiency of 62.7 per cent was obtained. It is to be noted that this pattern sweep efficiency is greater than Fig. 6 by approximately 11 per cent. This was brought about by the creation of a fracture at well No. 2 to partially offset the effect of the fracture at well No. 4. In previous figures it was indicated that the creation of a vertical fracture at well No. 2 in the direction shown might be expected to result in a sweep efficiency less than that which would be observed if no fracture had been created. However, Fig. 7 shows that the creation of a vertical fracture may result in an increase in sweep efficiency for this particular unique pattern. If wells No. 2 and No. 4 were not fractured a sweep efficiency of 57.9 per cent would be expected. However, the creation of the fracture at well No. 4 resulted in a decrease in sweep efficiency to 51.6 per cent. The creation of a fracture at well No. 2 resulted in an increase in sweep efficiency to 62.7 per cent.

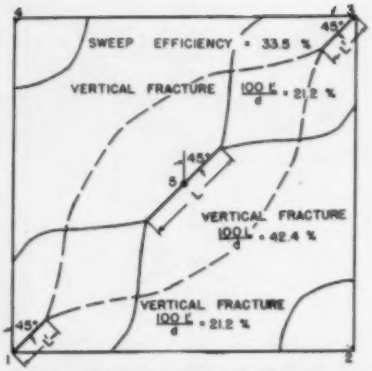

FIG. 9. **Three In-Line Fractures** in diagonal line across five-spot pattern and resulting efficiency.

Fig. 8 shows the sweep efficiency when a vertical fracture that is 42.4 per cent of the well spacing exists at well No. 5 and a vertical fracture that is 21.2 per cent of the well spacing exists at well No. 3. A sweep efficiency of 27.5 per cent was observed. The

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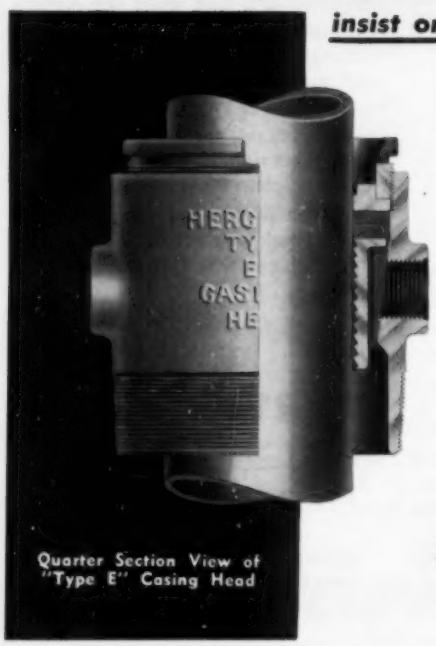

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fluid flux were 27.0, 21.9, 29.2 and 21.9 for wells No. 1, 2, 3 and 4, respectively. Had no fracture been created at well No. 3 a sweep efficiency of 57.9 per cent would be expected. Creation of the fracture at well No. 3, however, resulted in a decrease in sweep efficiency to 21.2 per cent.

Fig. 9 shows the sweep efficiency of a vertically fractured five-spot pattern that has a vertical fracture 42.4 per cent of the well spacing at well No. 5 and vertical fractures 21.2 per cent of the well spacing at wells No. 1 and 3. If no fracture had existed the sweep efficiency would have been near 72.3 per cent. If only the fracture at well No. 5 had existed a sweep efficiency of 57.9 per cent would have been expected. If the fractures at wells No. 5 and No. 3 had existed a sweep efficiency of 27.5 per cent would have been expected. By creating a fracture at well No. 1 resulting in the pattern shown in Fig. 9, a sweep efficiency of 33.5 per cent was obtained. The fluid flux for wells No. 1, 2, 3 and 4 were found to be 39.6, 10.4 39.6 and 10.4, respectively.

Fig. 10 shows the sweep efficiency of a vertically fractured five-spot pattern in which the center well possesses a fracture that is 42.4 per cent of the well spacing and wells No. 1 and 4 possess a vertical fracture that is 21.2 per cent of the well spacing. The fractures are oriented 45 deg as shown. Breakthrough occurred between wells No. 4 and 5. At this particular time a swept area of 41.2 per cent resulted. If only the fracture at well No. 5 had existed a sweep efficiency of 57.9 per cent would have been expected.

If only the fractures at wells No. 5 and 4 had existed a sweep efficiency of 27.5 per cent would have been expected. Creating a third fracture at well No. 1 resulted in an increase in sweep efficiency to 41.2 per cent. Had well No. 2 been fractured rather than well No. 1, the resulting sweep efficiency would have been 33.5 per cent. If only wells No. 1 and 5 were fractured (see Fig. 6) the sweep efficiency would have been 51.6 per cent. Then if well No. 3 had been fractured the resulting sweep efficiency would have been 62.7 per cent.

Fig. 11 shows the sweep efficiency of a vertically fractured five-spot pattern when the center well is unfractured, but wells No. 1 and 3 possess vertical fractures that are 21.2 per cent of the well spacing oriented as shown. The vertical fracture at well No. 1 extends directly toward well No. 5, whereas, the vertical fracture at well No. 3 extends directly toward well No. 4. A sweep efficiency of 38.4 per cent occurred. The fluid flux at wells No. 1,

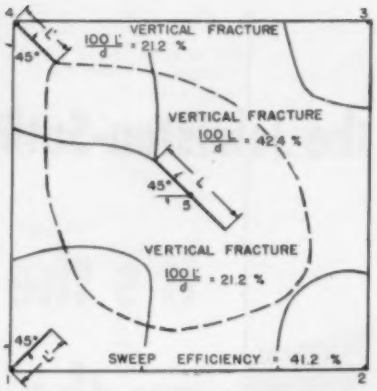

FIG. 10. **Three Wells Fractured** as shown in five-spot pattern produced a sweep efficiency of 41.2 per cent.

2, 3 and 4 were found to be 43.9, 10.5, 35.1 and 10.5, respectively.

Efficiency Varies from 0 to 71.3 Per Cent

Potentiometric model studies have been made to estimate the sweep efficiencies of vertically fractured five-spot patterns. It was found that the sweep efficiency might vary between zero and 72.3 per cent, depending upon the length and orientation of the fracture. For the particular patterns studied it appears that the creation of single fractures at the center well of a five-spot pattern may not result in a substantial increase in sweep efficiency over that which would be observed if the pattern were unfractured.

It was found that for fracture lengths up to 20 per cent of the well spacing the sweep efficiency may be between 50 and 71 per cent, depending on the orientation of the fracture. For a fracture length of 50 per cent of the well spacing the sweep efficiency might vary from 18 to 62 per cent. In general, creation of a longer fracture is expected to result in a decrease in sweep efficiency.

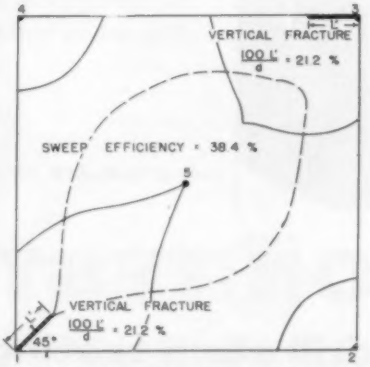

FIG. 11. **When Center Well Is Unfractured and two diagonal wells fractured as shown, efficiency was 38.4 per cent.**

It was found that for certain fractured patterns it may be possible to create a second or third fracture at corner wells which would result in an increase in sweep efficiency over that which may exist for a particular single or multiple well fractured pattern. For the patterns studied here the greatest improvement in sweep efficiency was effected by fracturing a corner well with a vertical fracture that was perpendicular to the existing vertical fracture at the center well.

Some comparisons may be made of the effect of vertical fractures on sweep efficiencies of five-spot and line-drive patterns.[1] For the line-drive pattern it was shown that if a long vertical fracture originated at one well and extended directly toward an adjacent well, this pattern might be flooded with an increased sweep efficiency if flooding were conducted perpendicular to the fracture.

In reviewing Fig. 3, it is evident that if the above type fracture existed the use of such a fractured well as the center well of a five-spot pattern would result in a very low sweep efficiency. If the total fracture length were up to 50 per cent of the well spacing and oriented to coincide with the "y" axis as shown, then it may be desirable to employ the five-spot pattern when flooding or cycling.

It is concluded that a detailed study should be made of any fractured pattern in which a water flooding or gas cycling program is to be conducted to insure that desired sweep efficiencies are expected and that maximum recoveries may be obtained. It is desired to point out that the data that are presented here were obtained on a potentiometric model in which it is assumed that a reservoir is flooded at steady-state conditions, at a mobility ratio of one, and gravity effects are neglected.

Acknowledgment

The authors wish to acknowledge the aid and encouragement of Dr. George H. Fancher, director. William Streiff prepared the illustrations. Appreciation is expressed to the Research Committee for permission to publish the results.

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2. Horner, W. L., and Bruce, W. A., "Electrical Model Studies of Secondary Recovery," *Secondary Recovery of Oil in the United States*, Second Edition, API (1950) 193.
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★ ★ ★

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OVER 45 YEARS EXPERIENCE

Small Rig Economy BIG RIG PERFORMANCE

The N-45 is packed with the extra features that make a drilling rig fast and profitable on work up to 6500 feet. From the big 40 x 18-inch drum back to the 450-horsepower transmission, every component has been designed to stand up under hardest service. Shafts are oversized . . . a double hydromatic brake eases heavy loads when going in and a two-speed air clutch transmission, plus a torque converter, gives the "just-right" combination of speed and power for every load when coming out.

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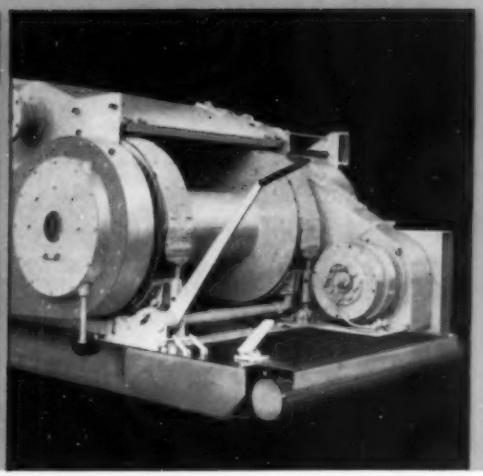
1. Torque converter drive 2. Two forward and one reverse speeds 3. Air-clutch transmission 4. Big 40" x 18" Drum 5. Finger-tip controls 6. Optional sand reel 7. Double hydromatic brake 8. Big 42" brakes 9. Enclosed water-cooled drums 10. Optional pump drive

BREWSTER N-45



FULLY AIR-CONTROLLED

From the driller's station there is finger-tip air control of drum, transmission, pump and rotary clutches. The driller can shift from low to high without stopping the load. An emergency positive drum clutch assures continued operation should air supply be cut off.

TORQUE CONVERTER DRIVE

The amid-ships torque converter will handle one or two engines. Combined with the two-speed transmission it provides flexible shock-free power for every operation. Chain life is extended and engines stay up to maximum efficiency regardless of load.

OVERSIZED BRAKES

Brake rims are 42 x 8 inches and cooled by an enclosed circulating water system. Self-energizing with 327 degrees of contact they are fitted with an equalizer for even wear. Either brake band will hold should the other be disconnected or damaged. The brake mechanism can be adjusted without removing the drum guard.

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BREWSTER MATCHED DRILLING EQUIPMENT FOR THE N-45 DRAWWORKS

MODEL HT-100 HOOK BLOCK

4-SX OILBATH SWIVEL

RSH-18 ROTARY

SPECIFICATIONS BREWSTER N-45 DRAWWORKS

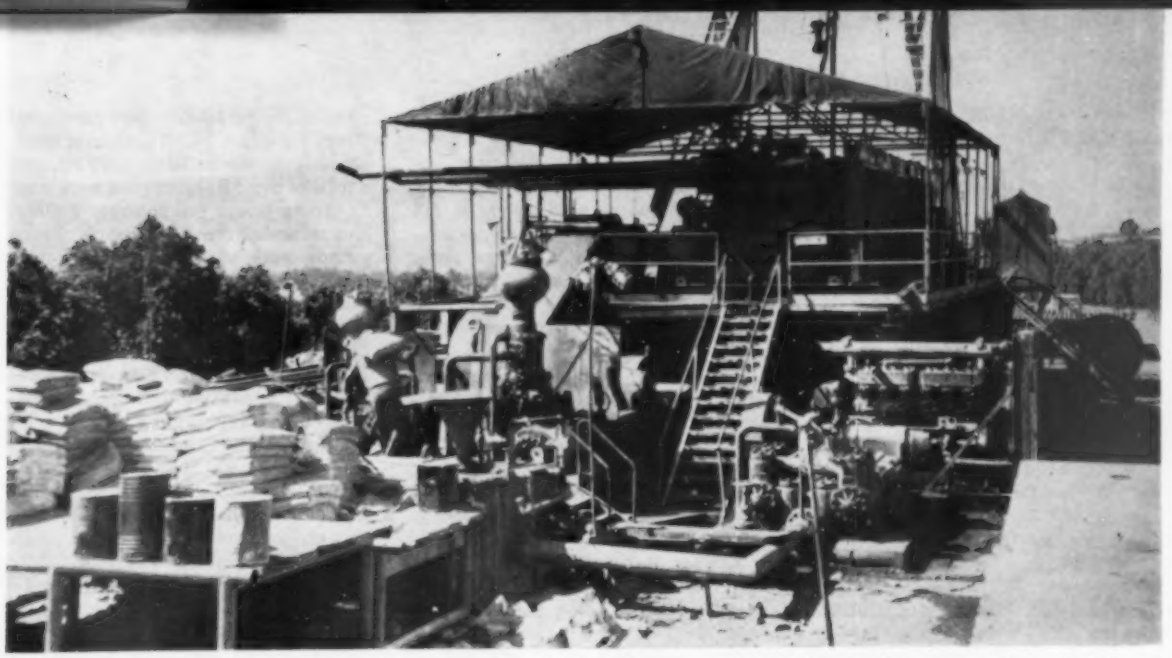
Recommended Horsepower	450 *	Forward Speeds	2
Diameter of Drum Flange	42"	Reverse Speeds	1
Diameter of Drum Spool	18"	Approx. Over-all Height	69½"
Length of Drum Spool	40"	Approx. Width and Length of Skid	75" x 20'-0"
Size of Brake Lining	1" x 8"	Approx. Weight of Drawworks less Engine	22,000 lbs.

**With torque converter equipped engines — 350 HP with amidships T.C.*

SPEED DIAGRAM

CONVERTER OUTPUT—*R.P.M.*	EFFICIENCY—%	PULL* LOW	PULL* HIGH	LINE SPEED *F.P.M.* LOW	LINE SPEED *F.P.M.* HIGH	ROTARY SPEED
0	0	52,000	18,800	0	0	0
335	70	34,000	12,250	196	544	48
1330	70	7,500	3,150	808	2,245	190

*Based on 450 H.P. at 1800 R.P.M.



FAST DRILL TIME was established by Rocky Mountain Drilling Company with this heavy-duty power rig in the Fillmore area of Ventura County. Biggest cost involved in location was purchase of one acre of orange trees.

P 425.26

FAST DRILLING RECORDS ESTABLISHED FOR DEEP WILDCAT

Careful mud control, tool selection keeps drilling costs at minimum

Jerry Stumm,
Pacific Coast Editor

ON June 26, 1955, exactly 82 days and 22½ hr from the time the well was spudded to the time of release by Standard Oil Company of California, Rocky Mountain Drilling Company completed the Sespe Creek Community No. 1 in the Fillmore area of Ventura County, California, at 16,100 ft, some 27 days ahead of the estimated time schedule.

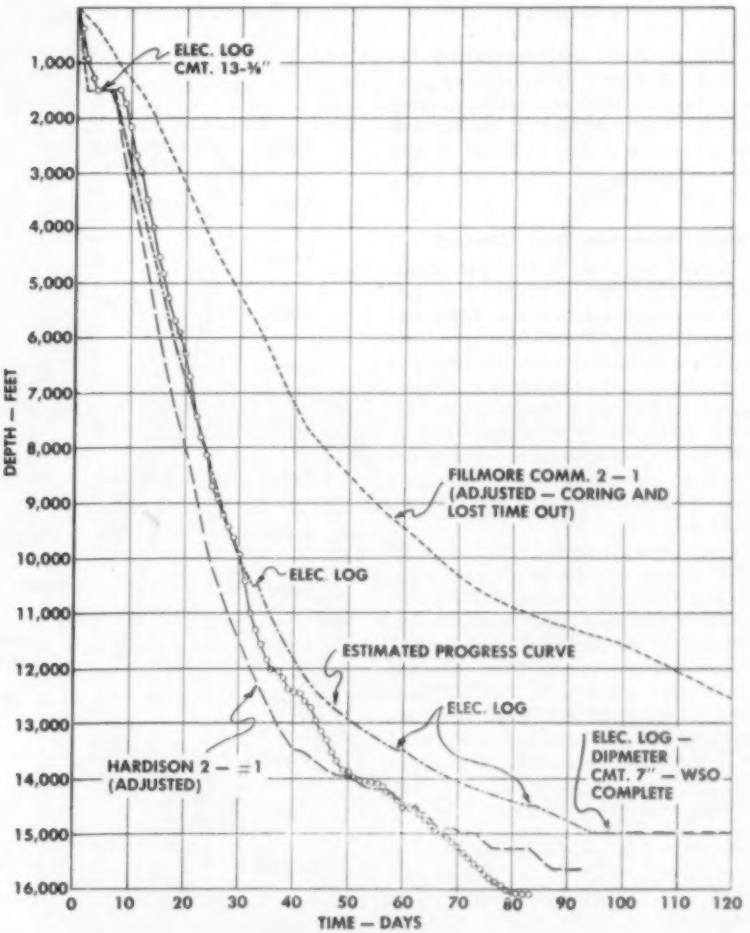


FIG. 1. DRILLING TIME CURVE for Sespe Creek Community No. 1 shown in solid line compared with two other wells in area. Also shown is curve on what the estimated drilling time would be.

This is fast digging when considering that in 1942, in the same area, Fillmore Community No. 1 took over a year to reach 15,000 ft.

Drilling Program

Except for 1460 ft of surface casing, the well was drilled entirely in open hole. The average drilling rate per day amounted to 194 ft. Formation conditions in the area consist of large boulders near the surface, giving way to sand, with Pico shale from about 7000 ft on down.

An 18⅝-in. surface hole was drilled to 1460 ft and 13⅜-in. casing set. The hole size was then reduced to 11-in. to 7104 ft. A 10⅝-in. hole was then drilled to 13,145 ft and 9⅞-in. to bottom.

In all, there were 109 rock bits used — ten 12¼-in. bits to drill surface hole; five 18⅝-in. bits to open surface hole; thirty 11-in. bits; twenty-five 10⅝-in. bits, and thirty-nine 9⅞-in. bits. Amount of hole per bit averaged 147.7 ft. There was also a total of 171 ft of core taken using eight 9⅞-in. core heads.

Rotary speed was maintained between 125 to 175 rpm and mud pressure between 1800 and 2000 psi, using 6½-in. liners. Weight on the bit was held between 20,000 to 24,000 lb and hole deviation did not exceed 2 deg 30 min.

Mud Program and Control

Mud used was a low pH lignite emulsion system. No clay or bentonite was used after the hole was under way as mud picked up sufficient formation solids to maintain its viscosity. Because a mud logger was employed on the job, diesel oil was used for water loss control, being added at about 7100 ft. Water loss, throughout the drilling operation, was maintained at between 3 to 3.5 cubic centimeters on a 30-min API test.

At approximately 11,500 ft about 500 grains per gallon of salt water began returning every round-trip. As there was no sand apparent on the electric log, it was concluded that the contamination was coming from fractured shale. Up to this point, mud had been maintained at about 80 to 82 lb per gal, with the viscosity ranging from 45 to 55 sec on Marsh funnel. With the evidence of salt water encroachment, the mud weight was quickly increased to 10.6 lb per gallon, holding the viscosity below 60 sec.

The salt water contamination continued every round-trip, so it was decided to allow the mud weight to fall back to about 9.5 lb, thereby conserving weighting materials. At the lower mud weight, the same salt water returns were in evidence, so the mud weight was maintained at the 9.5-lb level.

During this period of salt water contamination, and until the hole was completed, salinity of the mud remained from 200 to 330 grains per gallon. Despite the presence of this amount of salinity, the gel strength was maintained at 8 to 10 lb psf per 100 sq ft (Shearometer).

Needless to say, the hole was dry, but certainly represented a very economical wildcat drilled under less than desirable conditions.

Drilling Equipment That Set Record

To drill the Fillmore Community No. 1, Rocky Mountain Drilling Company employed a heavy-duty gas-fueled power rig with a 142-ft cantilever mast. Drawworks was rated at 1250 hp, and a total of five 510-hp engines were used to supply power for hoisting, drilling, and to power the slush pumps. Three pumps were used — two heavy-duty units, totaling about 1400 hp and one mixing pump rated at 350 input brake hp. Rocky Mountain's 100-ft kelly (*Petroleum Engineer, October,1955, p B-119*) was used, thus saving considerable time in making drill pipe connections during fast drilling.

The drill string consisted of 5-in. OD drill pipe to 7500 ft and 4½-in. external upset, internal flush pipe to bottom. Six 8-in. drill collars, totaling 270 ft were used to 13,145 ft, at which point the hole size was reduced to 9⅞-in. and six 7-in. collars were substituted to total depth.

Other Deep Tests in Vicinity

Two other deep wildcats were drilled for Standard in the same area during 1955, both dry, but with equally gratifying results from a purely eco-

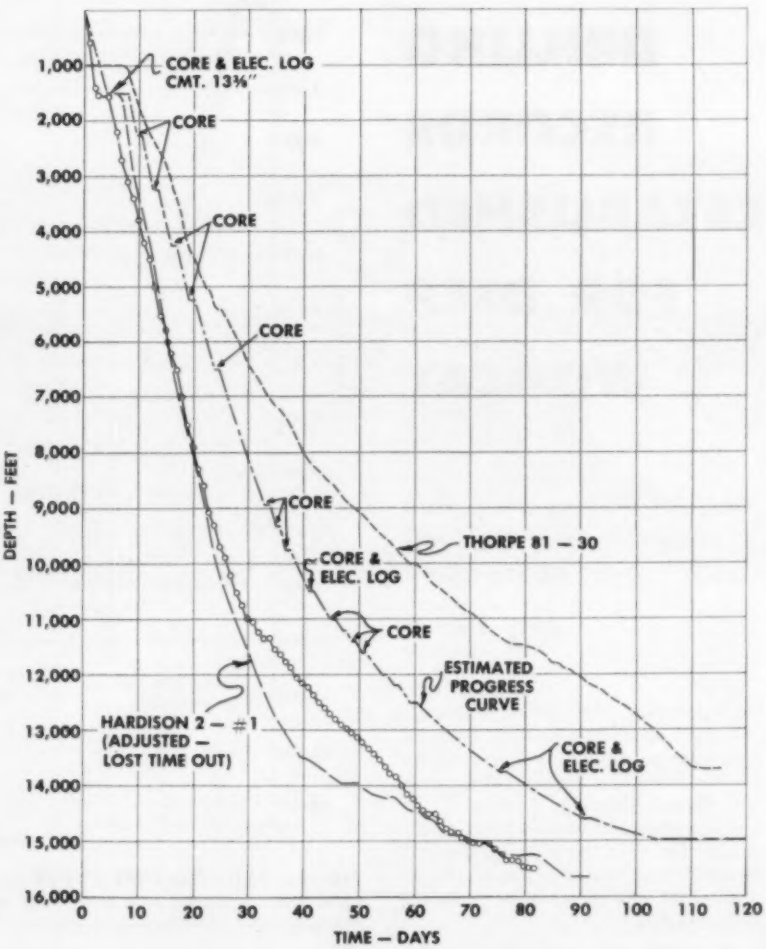
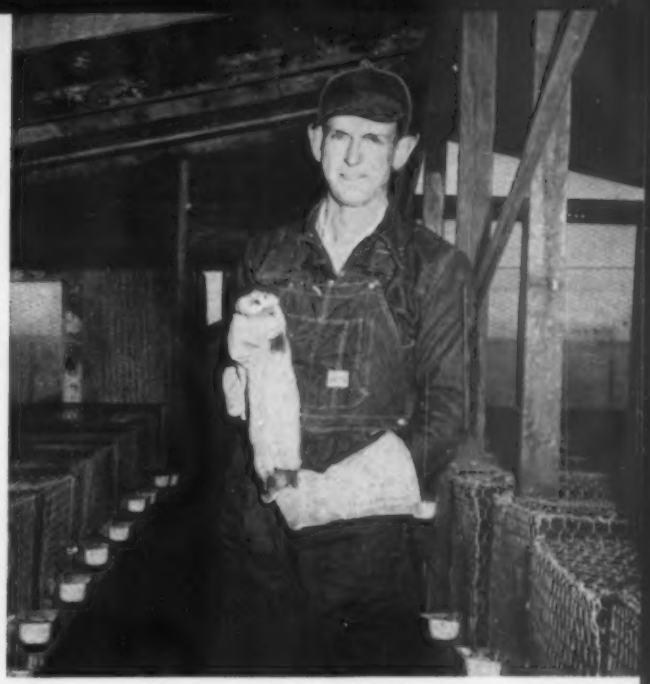


FIG. 2. DRILLING PROGRESS RECORD of another well in the area, the Yuba Consolidated No. 1, is compared with other wells. Estimated time for this well is also shown. Circles indicate actual time.

AXELSON PICTORIAL

SHOTGUN. Pat Pattishall (right), Senior Production Foreman for Continental Oil Company, Lyons, Kansas, shows off his new gun to "Preach" Bettis, Continental Oil Production Foreman (left), and "Stix" Wood (center), Axelson Representative. Continental Oil uses Axelson pumping equipment in several of their Kansas fields. Pat plans to use the gun for bagging pheasant and oil scouts. He uses the trailer exclusively for hunting and fishing trips.



EXPENSIVE HOBBY. V. M. "Steve" Stephens, pumper for Francis Oil & Gas, Inc., raises mink for a hobby. Like the specie they clothe, mink are mean and must be handled with gloves. They are kept in separate cages to prevent them from tearing one another apart. Steve lives on the lease outside of Great Bend, Kansas, and shoots jackrabbits for food for his mink. Steve has installed many an Axelson pump and rod. He says they wear as well as a mink coat.

AXELSON USI

PROUD OWNER. This pumper in the David Pool, Cowley County, Kansas, gets doting attention from Ben Grallap (left), partner of McNeish & Grallap (owners), and from N. F. Bryce, Manager of Jones & Laughlin store in Winfield, Kansas, who supplied all of the equipment used in this well. An Axelson Sure Seal pump (2"x 1½"x 10' 2") pumps 42 gravity oil from 2900 ft. Sucker rods in this well are Axelson ⅝ #60. Ben Grallap, a former land man with Shell, hit it big in this Kansas field. He is a great booster for Axelson pumps, sucker rods, and hydraulic pumping units.

(Advertisement)

WORLD'S LARGEST. Ross LeGate (left), Axelson Representative, working out of the Pawhuska office (Oklahoma), receives another pump order from Pete Blanda, Project Engineer for the Kewanee Oil Company. Tubing is being pulled on a well in the company's Fronkier Lease, Osage County, Oklahoma. Axelson sucker rods (the biggest selling rod in the world) are lashed to the mast, ready when lifting resumes. Waterflooding now in progress in this area (Burbank) is said to be the largest group of waterflood projects in the world.

AXELSON

USI

THE LONG PULL. With the mercury dropping to 8 degrees, Ed Ruble (left) and "Link" Cox pull tubing to check for leaks in the Gemeinhardt "A" No. 4, Bloomer Pool, Kansas (Atlantic Refining). D. H. Cook Oil Well Service is the contractor. Axelson sucker rods (lying on the ground just below the tongs) have performed well.

BLOOMER OPERATIONS. Carl Lohmann, Jones & Laughlin service man, checks a delivery from the Chase, Kansas, store to the rigsite during maintenance operations in the Bloomer Pool, Barton County, Kansas. J&L handle distribution and service for Axelson pumps and rods in 91 stores and 21 sales offices in the United States and Canada.

AXELSON PICTORIAL

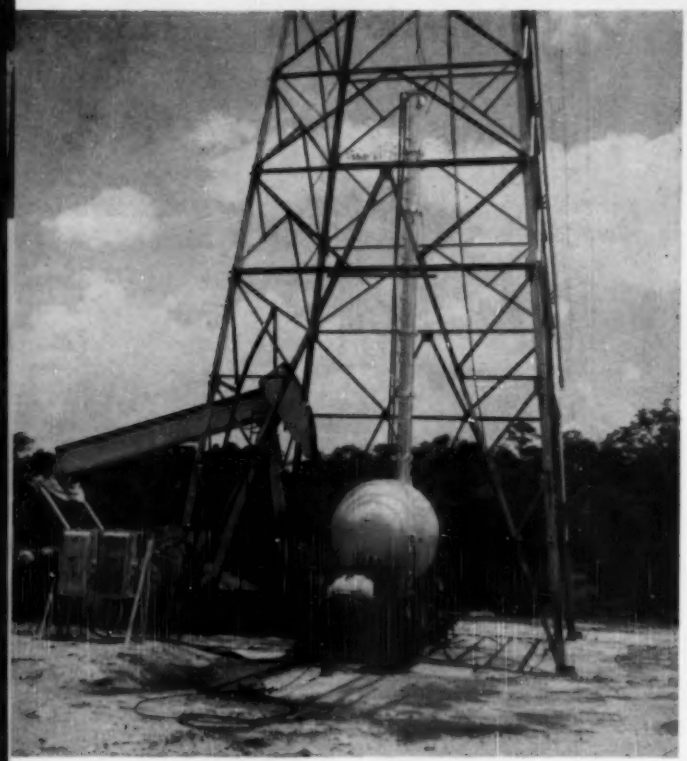
PERFECT MATING. Every ball and seat that goes into an Axelson deep well pump are perfectly matched pairs. They are machined together on special lapping machines and are carefully checked for fluid seal under a high-pressure vacuum test. The ball is turned in every direction on its precision-ground seat. The slightest quiver of the vacuum gauge needle means rejection. Running the test is Joe Villo who has been with Axelson for 32 years.

KANSAS BEEF. Cattle graze in Shell Oil Company's Radenberg Lease, Barton County, Kansas. Well pullers report that this is "enemy territory" when the bulls are in a greasy mood. D. C. McCoy, Field Supervisor, says that the cows aren't hard to get along with on the hoof. "It's when they're cooked and served in restaurants that they really get tough." Axelson equipment keeps many of the wells in the Radenberg Lease pumping.

STANDING in front of the Burmeister No. 1 in the Kraft-Prusa Field, Barton County, Kansas, is Shell Oil Company's well-service crew. This well, completed March 8, 1938, was equipped with Axelson sucker rods and an Axelson tubing liner pump (3″x 10′) pumping from 3,278 ft. The only work ever done on this well was in '49 when the plunger was replaced. The original plunger had not failed, a larger one was specified when pressure dropped. Original pump and rods are still going strong after 18 years of continuous service. From left to right: V. F. Yates, Leonard Culver, R. C. Linke, G. P. Morgenstern, G. M. Dressel.

AXELSON PICTORIAL

ON TEST. Creole Petroleum Corporation tests this Axelson Long-Stroke hydraulic pumping unit at its Quiriquire No. 531 well in Eastern Venezuela. At the time, No. 531 was producing at the rate of 1, 150 B/D. T. J. Bush, Production Superintendent, calls the unit "The Rattlesnake" because of its odd shape and long neck. It increased production by 500 bbls. and pumped the well down for the first time. Axelson Long-Stroke units are particularly recommended for greater production at greater depths and at reduced pumping speeds. Many are in use throughout the oilfields of South America.



UNDERGROUND CARDIOGRAPH. Glen Bowlus (left) and Bill Thorn of Technical Service Co., Long Beach, are running a dynagraph test on the Axelson long stroke pumping unit at the Texas Company Well No. 10, Foix Lease, Santa Fe Springs, California. The test showed no overload on rods (28,400 lbs. stress on 1" surface rod at 7,882 ft.), no overload on gear unit (30 HP), counter balance OK, the Axelson 1¼" plunger pump was filling well. Stroke (6.38/min.) could be slowed to 6 with no loss in production.

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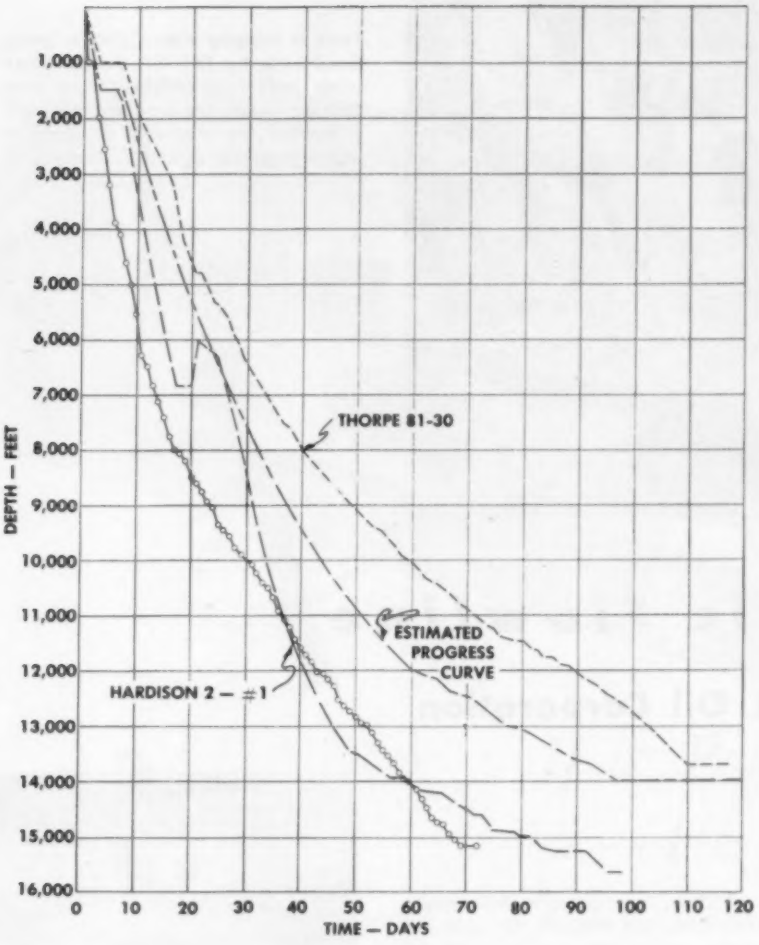


FIG. 3. THREE WELLS IN SANTA PAULA AREA are compared in these drilling progress curves to show other deep wells and how they compare with the Sespe Creek Community No. 1. Actual drilling time is shown in solid line with circles, compared with the estimated drilling time.

nomic standpoint. These were Vanderkarr No. 1, and Yuba Consolidated No. 1, both drilled by Drilling and Exploration Company.

Both wells were drilled with the same rig, which was comprised of a 1300-hp drawworks powered by four 400-hp gas engines with torque converter and an additional 400-hp gas engine on a direct drive to the rotary table. Mud pumps comprised a 600-hp side pump off the four-engine compound and a 500-hp tail pump off the same compound. A 143-ft full view mast was used on this rig.

Vanderkarr No. 1 was spudded on February 8, 1955, and the rig released 72 days later, on April 21, at a total depth of 15,157 ft.

Yuba Consolidated No. 1 was spudded May 28, 1955, and the rig released 83 days later, on August 19, after reaching a total depth of 15,550 ft.

Similar drilling conditions to the Sespe Creek Community No. 1 Well prevailed in these latter two wells, and both were drilling entirely in open hole following the setting of surface pipe. However, salt water was not present.

* * *

Pontoon Bridge Provides Access to Water Location

Throughout the coastal areas of the Gulf, there are numerous fields located in areas covered with water and wells must be located in swamps, marshes, lakes and bays. The problem of looking after these wells by the pumper and others concerned with the operation of the well is a knotty one from a transportation standpoint. In one lake area, this problem was solved by providing pontoon bridges from the bank out to the producing well to enable the pumper, engineer and others to inspect the well without the use of a boat.

The idea hinges around floating pontoons fabricated in the welding shop from salvaged oil drums. Three such drums are sealed by screwing tight the seal bung, and are then welded around the reinforced edges to form a long cylinder. Wooden cross pieces are strapped to these pontoons and tightened by bolts. The wooden walkway is attached to these wooden cross pieces to extend the walkway from land out to the well. A simple handrail was provided by bracing 2 x 4-in. uprights connected together by salvaged wire line. All service lines to the well, including fuel lines for the pumping unit engine are supported on this pontoon bridge. Each end of these services lines are equipped with flexible hoses to accommodate for any movement of the bridge due to changes in water level. The bridge idea resulted in considerable saving in this particular case, and provided an added convenience in checking the well and pumping unit.

Foot a minute pipe laying is being done here by TXL Oil Corporation using polyvinyl chloride pipe near Odessa, Texas. The crew laid this 2800 ft flowline for a new oil producer in less than one hour and 45 minutes.

First Plastic Flowline

Laid Quickly by TXL Oil Corporation

INITIAL field installation of polyvinyl chloride pipe in West Texas by TXL Oil Corporation has indicated new oil country applications for plastic pipe.

Recent laying of a 2800-ft flowline near Odessa using the PVC pipe suggests several weight, time-saving and non-corrosion advantages.

Line was laid in less than an hour and 45 min. A pipe laying crew coupled 90 lengths, one after the other, at the rate of almost a joint a minute. Pipe had been strung along a pre-cut ditch from the truck bed, the crew instructed and the entire line laid in less than three hours working time.

TXL used standard two-inch plastic pipe of normal impact type, with a plain end. The pipe was made by National Tube division of U. S. Steel Corporation. It has a maximum operating pressure of 195 psi at 75 F. Maximum operating temperature for the pipe is 150 F.

Very light, the pipe weighs .643 lb per foot. A total of about 3500 ft went into the TXL gathering line, all delivered in one truck load and weighing only 2250 lb.

The plastic pipe is non-corrosive and has high strength properties. Smooth inside surface permits maximum flow.

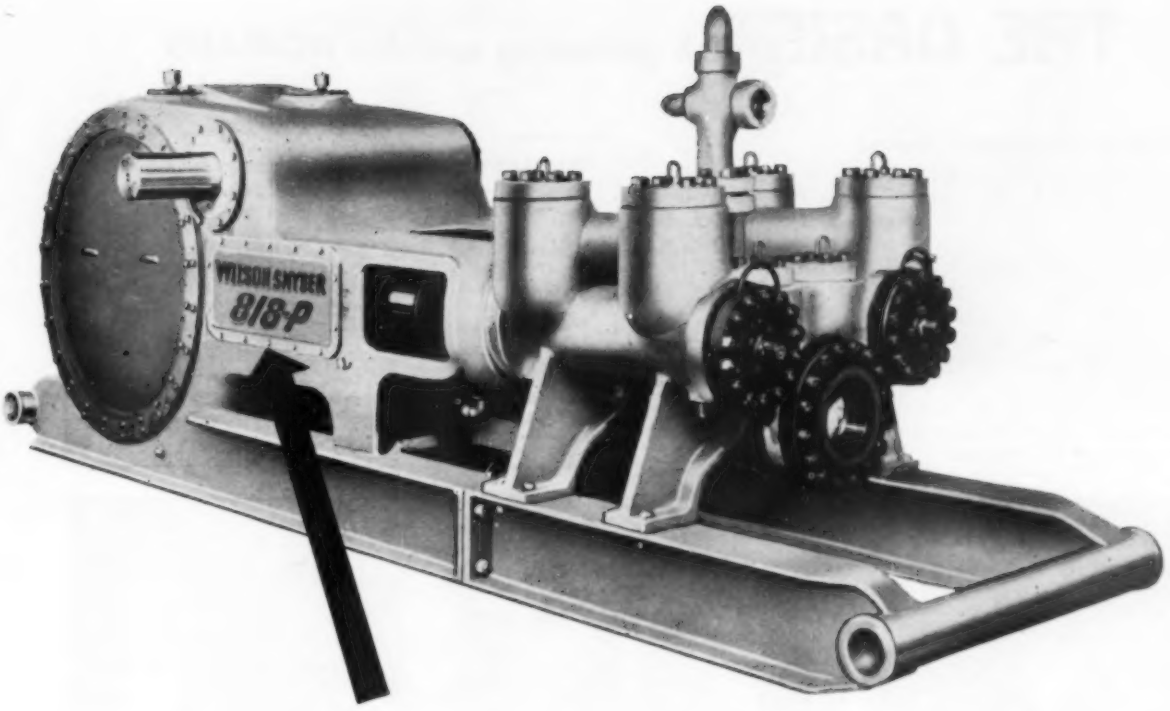
TXL laying operation was simple. The crew first cleaned the pipe and fitting socket with a cleaner (in this case, carbon tetrachloride), which was allowed to evaporate. Then both pipe and socket were quickly coated with a thin layer of solvent cement. After the cement coating, pipe and fitting were immediately engaged and either pipe or fitting quickly turned 90 deg to dispel air and improve surface contact.

In solvent cementing, 24 to 48 hours usually are required for the joint to reach full strength but initial strength was sufficient to allow continuous pipe line installation.

Manufacturers furnish the pipe in two strengths. One is normal impact type, for installations requiring high chemical resistance, with high strength and good creep properties. High impact type is designed for installations requiring chemical resistance and a high degree of toughness even at low temperatures. Each is made in both standard and extra-strong grades and is furnished in either plain or threaded end.

Pipe fittings are made of the same plastic material in most usual steel pipe types, as well as some peculiar to plastic, for complete plastic polyvinyl chloride fabrication. * * *

First oil field application of the plastic pipe is being checked by TXL Engineer William Kearley at its tie-in fitting. The two-inch plain end PVC pipe connected with a solvent cement, was used for gathering line at this new West Texas well.



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THE OASIS — *A gathering spot for NOMADS*

Los Angeles Committees Named

Los Angeles Chapter committees to serve this year have been appointed by President Harry Hester. Bill Wilson has been named chairman of the membership committee. Foreign contact committee chairman is John Isaacs; publicity chairman is Don Hanson. Visitation chairman is Charles McLaren, aided by Art Marshall, Ray Humphreys, and Chili Sutton.

The chapter's 1956 social season was off to a good start with its inaugural ball February 11. Dinner and dancing was in Sierra Room and Pacific Ballroom of the Hotel Statler. Orrin Tucker and his orchestra played for the group. Leading the group who planned and executed the ball was Bob Gaylord, acting as general chairman of the committees. Master of Ceremonies was Jim Hughes.

NOMADS Meeting Dates and Secretaries

New York Chapter, first Monday of the month, Biltmore Hotel, New York. Executive Secretary E. W. Hoeppner, in care of Hughes Tool Co., Room 4414, 30 Rockefeller Plaza, New York 20, N. Y.

Houston Chapter, second Monday. Ye Olde College Inn, Houston, Texas. Executive Secretary, Harry E. Estes, P. O. Box 14343, Houston 21, Texas.

Los Angeles Chapter, second Wednesday, Jonathan Club, Los Angeles, California. Executive Secretary, W. A. Sawdon, P. O. Box 848, Hollywood 28, Calif.

Tulsa Chapter, third Friday, Mayo Hotel. Executive Secretary, E. L. Thomas, P. O. Box 4033, Tulsa, Okla.

Dallas-Fort Worth Chapter, first or second Monday. Secretary, H. A. Davis, H. A. Davis Power Equipment Company, 2142 Irving Boulevard, Dallas, Texas.

TULSA CHAPTER'S fifth annual ball, January 26, featured the inauguration of officers. Shown here are Gilbert Swift, senior regent; R. C. Glover, past senior regent; Don L. Collins, president; H. M. Cooley, master of ceremonies; Cecil C. Crider, vice president; Guy F. Williams, treasurer; Oscar Irazarry, secretary; John Pearce, assistant secretary; E. J. Handley, sergeant-at-arms, and W. O. Timberlake, deputy sergeant-at-arms. Officers not shown here are Jack H. Beesley, junior regent, and Paul V. McGivern, assistant treasurer.

LA Adds Two Members

Two new members were inducted into the Los Angeles Chapter of Nomads at the December meeting. They are Ed Clark of Oilwell Supply Division, Associate Member, and Andy Anderson of Pacific Perforating Company, Regular Member.

TULSA'S GUESTS at its recent inaugural ball included 45 representatives of Jersey Standard from Iran, Iraq and South American countries attending Carter Oil Company's research school. Nomads hosts Oscar Irizarry, Petroleo Interamerican, and Guy F. Williams, Dowell, are chatting here with guests Ed Ojeda, Creole Petroleum, and John Eckel, Carter Oil Company.

DALLAS-FORT WORTH CHAPTER Nomads were hosts to the American Association of Oilwell Drilling Contractors at their January 23 meeting. At the head table are Courtney Berlin, Baker Oil Tools; K. Marshall Fagin, Southwestern Life Insurance Company; H. A. Davis, H. A. Davis Power Equipment; C. R. Athy, Maxwell Steel; Brad Mills, American Association of Oilwell Drilling Contractors; Eugene McElvaney, First National Bank of Dallas (speaker for the evening); R. E. Davidson, Drilling, and Gordon Wilbur, Ideco.

NEW MEMBERS initiation meeting was held by the Dallas-Fort Worth group January 23. Shown here are Webb Sowden, Hewett-Robbins Rubber; Ronald Roberts, Reed Roller Bit; King Boyd, Ideco; Donald Tarpenning, Chicago Pneumatic; Lee Howell, Stewart & Stevenson; Warren Thorson, Ideco, and Don Margo, Ken Corporation. At the same meeting, Nomads were hosts to the American Association of Oilwell Drilling Contractors.

Dallas-Fort Worth Chapter Elects 1956 Officers

Abbott Sparks, The Petroleum Engineer magazine, is president Dallas-Fort Worth Chapter for 1956. Executive vice president is R. E. Davidson, Drilling Magazine. Glen A. Tableman, WKM Manufacturing, is vice president (Dallas) and A. G. Evans-Lombe, Parkersburg Rig & Reel, is vice president (Fort Worth). H. A. Davis, H. A. Davis Equipment Company, is secretary. Harry Zane, Guiberson, is assistant secretary. Gordon G. Wilbur, Ideco, is treasurer. A. M. Birnie, Security Engineering, is assistant treasurer. Herschel Lewis, Emsco D+B, is sergeant-at-arms. Lewis Foster, Foster Cathead, and Bob Gilmore, Degolyer-MacNaughton, are deputy sergeant-at-arms. Regents are Ted Mayborn, Drilling magazine and C. R. Athy, Maxwell Steel.

THE LINE-UP of Dallas-Fort Worth Chapter officers for 1956 is Glen A. Tableman, R. E. Davidson, A. M. Birnie, Gordon Wilbur, Abbott Sparks, Ted Mayborn, C. R. Athy, Herschel Lewis, Harry Zane, R. E. Gilmore, H. A. Davis, and J. Lewis Foster. A. G. Evans-Lombe is not in the picture.

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Part 8 | **Field Operations**

Elements of Water Injection

A constant check of performance is essential to fulfill advanced expectations of a flood

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IT has been said that when "we stop pedaling we coast backwards." This homely expression is particularly true from the time the first barrel of water is injected. Secondary recovery is not the essentially automatic process that describes much of the primary production. Additional effort and guidance are required to reconcile actual field performance with advance expectations. A typical flood in operation will lose momentum and collapse prematurely if neglected. The keynote is the control of how much water goes where and when in the pay zone.

Input Well Behavior

Study of the performance characteristics of input wells provides evidence that can be interpreted in terms of important factors such as plugging of the sand face, plugging within the reservoir at a distance from the well, permeability distribution over the net thickness, degree of reservoir fillup with water, and channeling. A set of well tests taken at one time is highly useful in itself, but the comparison between results obtained at successive times can be even more revealing. Comparisons made between wells at the same time give information used in controlling the advance of the injected water. Only in theory does water from each of the four input wells in a five-spot simultaneously reach the producer.

Injectivity index. Injectivity index describes an injection well the same way productivity index describes a producing well. Injectivity index is the barrels of water per day admitted to the reservoir per pound pressure difference between flowing and static conditions. Since this index relates to the permeable capacity of the well, variations in the index with time either help confirm predicted performance or gives early warning of future trouble.

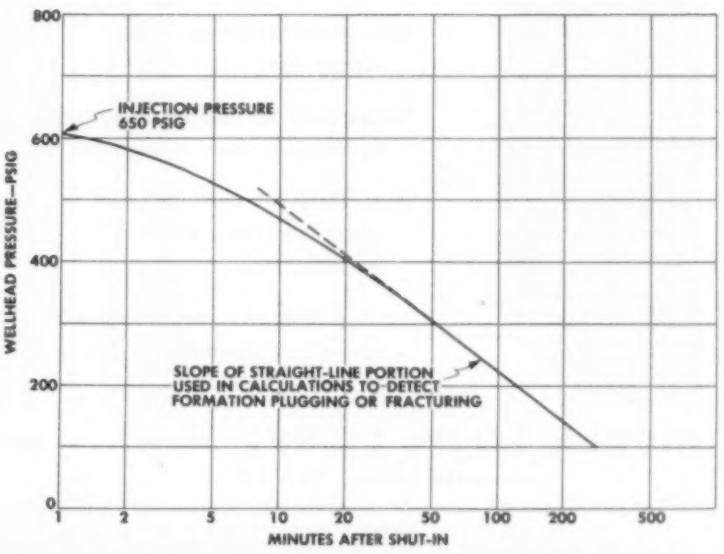
Pressure-decline curve. Another valuable indicator of well performance is the bottom-hole pressure decline curve, which is equivalent to the more familiar build-up curve for producers. After considerable water has been injected, the bottom-hole pressure is recorded, then injection is stopped, and pressures recorded for the next hour or two. Water in the higher pressure area nearest the well will distribute itself radially. Pressure in the well bore will decline, rapidly at first, then more slowly to level off toward the average reservoir pressure.

Analysis of this curve will indicate the final static pressure, the average permeability in the injection radius, and the "Skin Effect" factor, which relates to sand face plugging. If the pressure-decline curve is run early in the life of the injection well, there is a relative standard to which later findings can be compared.

Well cleanout and remedial work is expensive. Pressure analysis not only can suggest the most effective treatment to be given but also can point out the degree of improvement that can be expected. It can save expense by eliminating repeated unsuccessful workovers on wells that show no theoretical basis for ever being improved.

Down-hole instrumentation. Unfortunately, water injected over a given net pay thickness will not move away from the well in equal quantities for each foot of thickness. The more permeable streaks or fractures transfer water away from the well at the higher rates. For an unfractured pay, complete core analysis of the entire section will reveal the vertical distribution of permeability—the permeability profile.

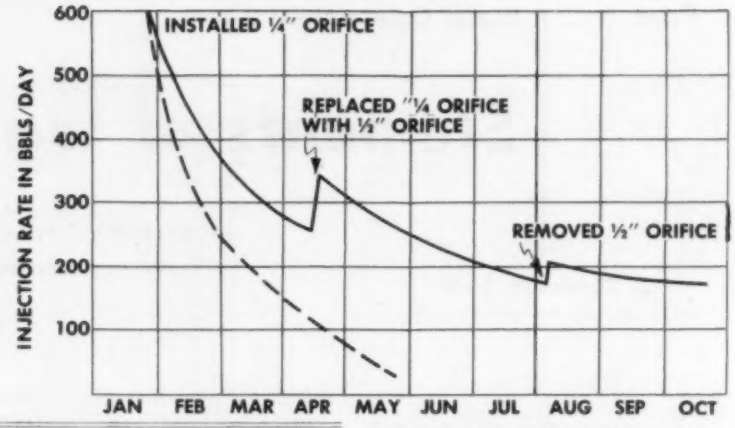
Equipment and methods have been developed for obtaining this profile of injection wells where core analysis is not available. Although the methods generally lack precision, results of some quantitative value are obtainable These instruments operate on the basic principles of fluid velocity, radioactivity, or temperature gradient anomalies, which may be detected over the depth interval represented by sand thickness.



Typical Pressure Decline Curve for an injection well after it has been shut in. Analysis will indicate final static pressure, average permeability in the injected radius, and the "Skin Effect."

Flowmeters. Velocity-type instruments make use of the fact that vertical velocity is greatest just above the top of the sand and is zero at the bottom for a given hole diameter. The deceleration of the flow is proportional to permeability. One form of the device is a small fluid turbine with a rotating shaft electrically equipped to record rpm. This equipment has been found useful in identifying regions of high water intake and in determining the relative intake capacities of multiple zones in the same well. Precision readings over thin sections and at low velocities should not be anticipated.

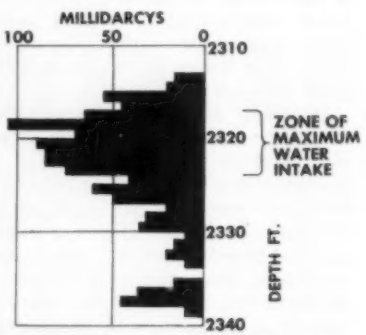
A more recent instrument utilizes a modification of the rotameter principle, which may simply be described as equivalent to a ball and seat valve. The higher the flow rate, the farther the ball moves from the seat, with distance of ball travel being the measurable quantity.



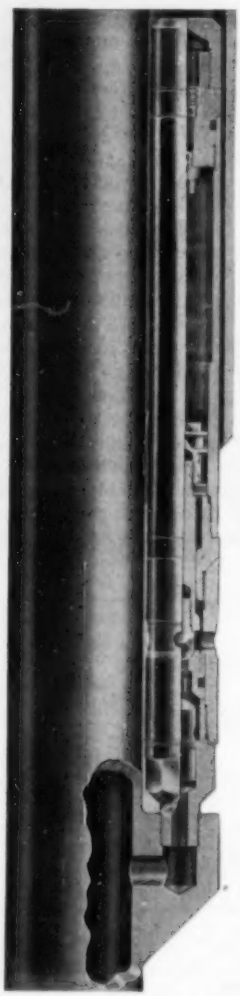
Injection Rate-Time Curve for a controlled dump flood. Dashed curve indicates what might have happened if the untreated flood water had progressively plugged the pay zone.

Radiotracers. In the radiotracer process, a gamma ray log is first run for reference purposes. A radioactive isotope is then injected at the surface and traced during its progress down the well. The detection of downward velocity variations is possible. The isotope will be deposited on the sand face in general proportion to the permeability of the pay to water at each point. Results are, therefore, not indicative of permeability alone but rather to a composite permeability-liquid saturation factor.

By running additional logs of the



Permeability Profile of Sand Section as cored in injection well. It is the function of subsurface flowmeters to reproduce not only the essential features of the profile, but also to reveal fractures or thief zones not indicated by coring.



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hole after the isotope injection and by comparing with the original reference log, the zones most receptive to water are determined. Where hole diameters are uniform and the formation is not fractured, representative data can be obtained.

Temperature surveys. In the temperature method for determining the permeability profile, it is the variation in temperature gradient with depth and the temperature build-up relationships with time after shut-in that are subject to analysis. The temperature survey technique is most applicable in locating thief zones that divert large quantities of water and, like the turbine-type meter, in determining water distribution between separate strata. The temperature recorder gives good data on overall thickness of the intake zone.

Rate-time curves. Not requiring special subsurface tests are the continuously recorded data on total water injected in each well and the intake rates. Highest rates are attainable initially. As the formation becomes liquid saturated, the intake rate normally declines logarithmically with time. Injection pressures may be increased advantageously until reservoir fill-up is achieved. This normal rate decline should be anticipated and distinguished from formation plugging.

After fill-up, the injection rate may be on the order of one-fourth the maximum initial rate. Interpretation of the rate-time curve for each well as compared to similar injection wells can furnish interesting ideas concerning possible difficulties at the injection well, at the producers, with sand continuity and general permeability-saturation conditions.

Barrels per foot. Injection rates are frequently discussed in terms of barrels per day per foot of pay. Rates on the lower end of the range (from 1 to 10) are common. It might not be disturbing to encounter 20 bbl per day per foot for a 100 md sand with low liquid saturation. Unless in clean, uniform sands, excessive rates make one suspicious of fractures or thief zones.

Water Shut-Off

Flood nipple. The objective in producing-well operation is to produce as much oil as possible with the least water. If the oil and water are flowing together, not much can be done about the water except produce it, too. Some operators have used the "flood nipple" effectively down the hole. Production is taken from the bottom of the hole to keep the water removed, water being the heavier liquid. Purpose is to retain a column of oil rather than water across the sand face. To accomplish this, a small hole is drilled in a tubing collar above the sand top so that the fluid level cannot be pumped down below the sand top.

Selective plugging. Under some conditions, wells highly cut with water can be successfully worked over. This opportunity exists when water and oil are being produced from separate zones within the pay. Initial water breakthrough may be expected in the most permeable zones first. Water performance after breakthrough, together with knowledge of stratification from logs or coring, provides the key to the desirability of remedial action. Channeling of water is evidenced by the appearance of water in a producer too soon after the start of injection or by constant water-oil ratio with time.

The first and simplest test is to vary water injection rates. In some cases, this can control producing water-oil ratios. Failure in this would suggest some form of selective plugging either at the input well or the producer or both. Several methods are available. For example, a specific section of the input well, determined from profile tests, may be "mudded" off easily by squeezing first a moderate-viscosity mud followed by a thickened mud. This might then be followed by a cement squeeze with fibrous material

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added to fill the larger crevices. A kerosine-current squeeze has been recommended for squeezing bottom water from producers in fractured pays. In this application, the cement will set only where in contact with water, and the oil-saturated sections may be washed with acid for removal of the cement.

Similar to this is the squeezing of a bentonitic material in an oil-base carrier. The action here is for the bentonite to swell and plug only the water-bearing zones. Plastic squeezes have been used.

Selective shooting and raising or lowering the pump barrel are commonly employed measures for water-oil ratio control. The savings in lifting costs justify reasonable efforts to eliminate unnecessary water from the well stream.

Innovations

Various unusual techniques have been suggested in the past for increasing waterflood recoveries. The facts appear inadequate to justify making recommendations or dire predictions concerning them at this time. It will be interesting to watch the progress of these newer developments with particular emphasis on the limits to their applicability.

Wetting agents. One of these methods involves the addition of detergents or wetting agents to the input sand. These additives probably help when the sand grains are originally wet with oil rather than with the connate water. This situation is the less frequently encountered in the occurrence of oil. The major drawback is that adsorption of the wetting agent on the sand grains nearest the injection well prevents movement of the detergent outward toward the water-oil front where it can exert maximum effectiveness.

Of the three types of surfactants, the nonionic shows least adsorption. Because of this inherent loss of wetting agent, it is difficult to demonstrate that the possible additional recovery of oil will justify the actual additional cost.

Carbon dioxide injection. The injection of gaseous and liquid carbon dioxide (CO_2) and carbonated water has been tried at least experimentally. Some spectacular results have been obtained in reducing residual oil saturation. The principle of the method is to make use of the marked expansion of crude oil when this gas goes into solution with oil. It has been suggested that CO_2 treatment be applied to old water-drive fields. Because of the large quantities of CO_2 required to yield significant results, the method suffers from unfavorable economics more

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Use of gas. In the eastern producing areas, natural gas has been extensively injected immediately before and some times during waterflooding with some beneficial and no harmful effects. Residual gas saturation in the pore space appears to assist in the oil recovery process.

Acidization. Consistent with the principle that bentonitic materials are not dispersed by low pH solutions, the injective capacity of input wells in dirty sand reservoirs is being increased through massive acid treatments. This procedure may reopen for flooding consideration certain reservoirs poorly regarded due to the presence of swelling-type clay materials.

Intermittent production. Another technique used by some in flowing floods is the practice of pressure surging. This is accomplished by shutting in each producer for a few hours each day. This allows localized pressure build-up and tends to force the injected water into the less permeable streaks. Advocates claim an improvement in the volume of sand swept by the water, hence an increase in ultimate recovery.

Cross Flooding

When a pattern flood approaches its economic limit, there is yet another device that can be tried to rejuvenate the flow of oil. The flood water has established certain paths for its travel between the inputs and the producers. If, now, the pattern be revised so as to break up these paths by shifting the direction of pressure gradients, previously unswept volumes may be producible. In the five-spot, this is done by abandoning all existing inputs and converting the alternate producers to injection service. Reducing the number of producers in this manner increases the well spacing and effectively rotates the pattern through 45 deg. Modifications of this may be devised for other patterns and to fit existing wells where random location was the rule.

Water-Oil Ratios

There are two ratios that assist in judging flood operations: (1) The cumulative produced water-oil ratio and (2) the cumulative injected water-oil ratio. The ratio of produced fluids starts low and rises with time. The injected water-oil ratio starts high and decreases with time as the effects of the flood are felt. Whenever this latter ratio declines to, say, 10 to 1, operations may be considered to be going very satisfactorily. A ratio of 2 to 1, which has been experienced in practice, is phenomenal. Very low ratios imply that both oil and total liquid

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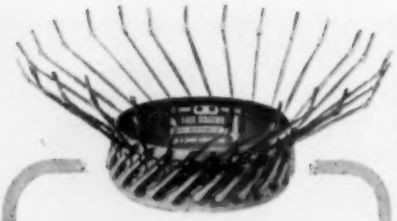

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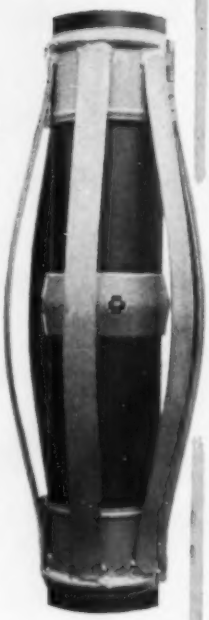

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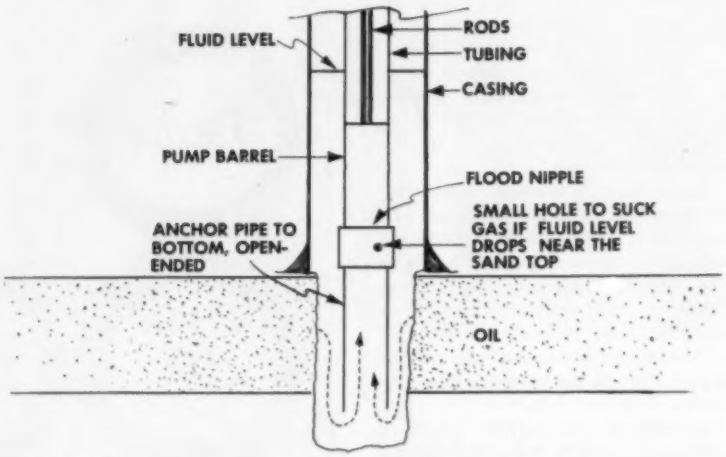
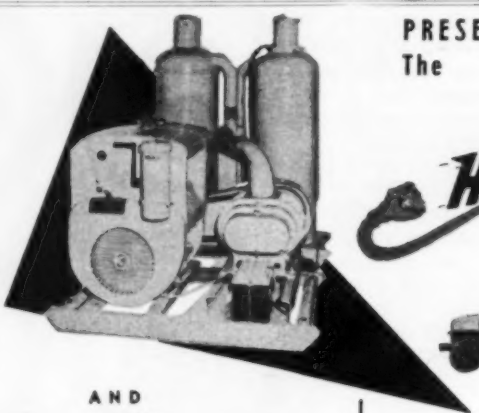


Flood Nipple in Producing Well to prevent water that flows into well bore from standing against the oil-saturated sand face.

saturations were high before the start of the flood and that negligible water was required for reservoir fill-up.

Since the total water injected exceeds that produced for floods in depletion-type reservoirs, the cumulative injected water-oil ratio will always be higher than the cumulative produced ratio. At the economic limit of the flood, one may expect to have pumped some 10 to 15 times as much water as oil. Consistent effort taken in the field to keep the ultimate cumulative produced ratio as low as possible will help protect or increase anticipated profit from the operation.

Part 9—"Recoveries and Profit" is the concluding chapter of this instructive series. Its purpose is to present some condensed thoughts on oil recovery and factual ideas on profits from flooding.



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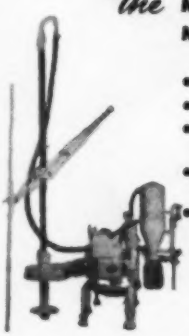

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EXPLORATION ACTIVITIES

OKLAHOMA

★ Discovery of a new natural gas condensate reserve in Beaver County, the Sleeper Well No. 1, has been made by Orville H. Parker, Ponca City oil and gas operator. Drillstem test ran from 7661 to 7731 ft showed gas to the surface in 30 seconds, and in nine minutes gas was producing at the rate of 7,120,000 cu ft daily. Condensate came to the surface in one and one-half minutes; bottom hole pressure was 2190 psi and final flow pressure was 1525 psi.

★ East Standard's Hay No. 1 in Noble County, Oklahoma, flowed from the first Wilcox and Skinner zones at the rate of 371 bbl per day of 30 to 40 gravity oil with 1000 lb of casing pressure. Allowable production is 64 bbl per day in this area on the basis of a dual completion. The well showed evidence of productivity potential in the Oswego, Checkerboard and Layton zones.

★ British-American Oil Producing Company has completed the state's deepest producer to indicate potentially large oil and gas reserves below 15,000 ft in the Ordovician Bromide sand. The company's No. 2 Harrison on preliminary tests, through small size chokes, produced high gravity oil or condensate at rates ranging from 30 to 40 bbl per hour, with gas estimated at 5,500,000 cu ft per day. The well was completed in 60 ft of open hole from 15,250 to 15,310 ft after 5-inch liner was run from 14,664 to 15,250 ft. The well was spudded on June 14, 1955, and after exactly eight months of drilling and testing, completion was made on February 14, 1956. At a depth of 14,931 ft, 7-in. casting was cemented to set a new casing record for Oklahoma. Additional oil and gas has been indicated in the McLish and Oil Creek sands.

TEXAS

★ Completion of The Texas Company's J. H. Shirk Estate "A" No. 1 Wolfcamp discovery as a 160-bbl per day oil well in southwestern Upton County, has been announced. Total depth drilled was 11,098 ft and the well was plugged-back to 7220 ft. Perforations are 7170-7190 ft. The well is about two and one-half miles south of the nearest production in the King Mountain field.

★ Cities Service and Seaboard have a new Permian limestone discovery 12 miles west of Seminole, in Gaines County. After swabbing, the Corrigan No. 1 flowed 176 bbl of oil in 14 hours from perforations between 8742-8758 and 8762-8777 and 8780-8786 ft. Flow was through 32/64-in. choke and the flowing tubing pressure was 50 psi. The gas-oil ratio was 50 to 1. During the last seven hours of the test, the well flowed at the daily rate of 283 bbl of 29 deg oil. The discovery is three miles south of Devonian production in the Alsabrook field and is on a 630-acre drilling unit.

★ Shamrock Oil & Gas has opened a new Hepler sand oil pool in central Hansford County of the Texas Panhandle. The well is six miles northeast of Gruver and is the No. 1 Elizabeth M. Long. It flowed 320 bbl of oil from perforation at 6281-87 on a half-inch choke. Gas-oil ratio is 1130 to 1. Total depth of the discovery is 6295 ft.

★ D. W. St. Clair, Midland operator, has completed a flowing Clear Fork oil discovery in Gaines County. His No. 1 Branch wildcat, located 10 miles southwest of Seminole, was completed for a 24-hour potential of 308 bbl of 35 deg oil. Production was through perforations at 7114-220 ft on a 1-in. surface choke.

★ J. C. Williamson, Fort Worth, has confirmed and extended the North Means-Queen field of south central Gaines County at its No. 3 Crews-Mast. The well, drilled to 4370 ft, was perforated in the Queen sand at 4316-26 ft. It flowed 509 bbl of oil, with gas-oil ratio of 550 to 1 on initial potential test.

★ William L. Rogers, Fort Worth, has opened Clearfork production in the Kelly Snyder-Canyon zone field of Scurry County. Rogers' No. 1-A Iona Williamson, more than 2 miles from nearest Clearfork production, pumped 83.3 bbl of 23 deg oil a day on completion test. Hole was drilled to 3597 ft and casing was perforated in four intervals at 3320-80 ft and fractured.

★ Texas Pacific Coal and Oil Company's latest oil strike came in with successful testing of the No. 1 Jacobs Livestock Company exploratory well in the South Egolf area of Upton County. Drill stem tests in the Ellenburger from 10,545 to 10,641 ft flowed 45 bbl of oil for the first hour and 41 bbl per hour for the second and third hours. Gravity is 49 deg and gas-oil ratio is 489 to 1. Earlier drillstem tests indicated shows of oil in sands above the Ellenburger. Texas Pacific holds 2,200 acres around the Jacobs Livestock discovery well.

SOUTH DAKOTA

★ Sun Oil's No. 1 Government-Gregg wildcat in Harding County has had promising shows on two drillstem tests. The well is six miles northeast of the two-well Custer field. Red River sand was topped at 9192 ft and on test at 9220-60 ft there was recovery of 270 ft of free oil and 450 ft of oil and water (10 per cent oil), and 1710 ft of water. On second test at 9261-9308 ft, there was recovery of 720 ft of oil and water (5 to 50 per cent oil).

ALASKA

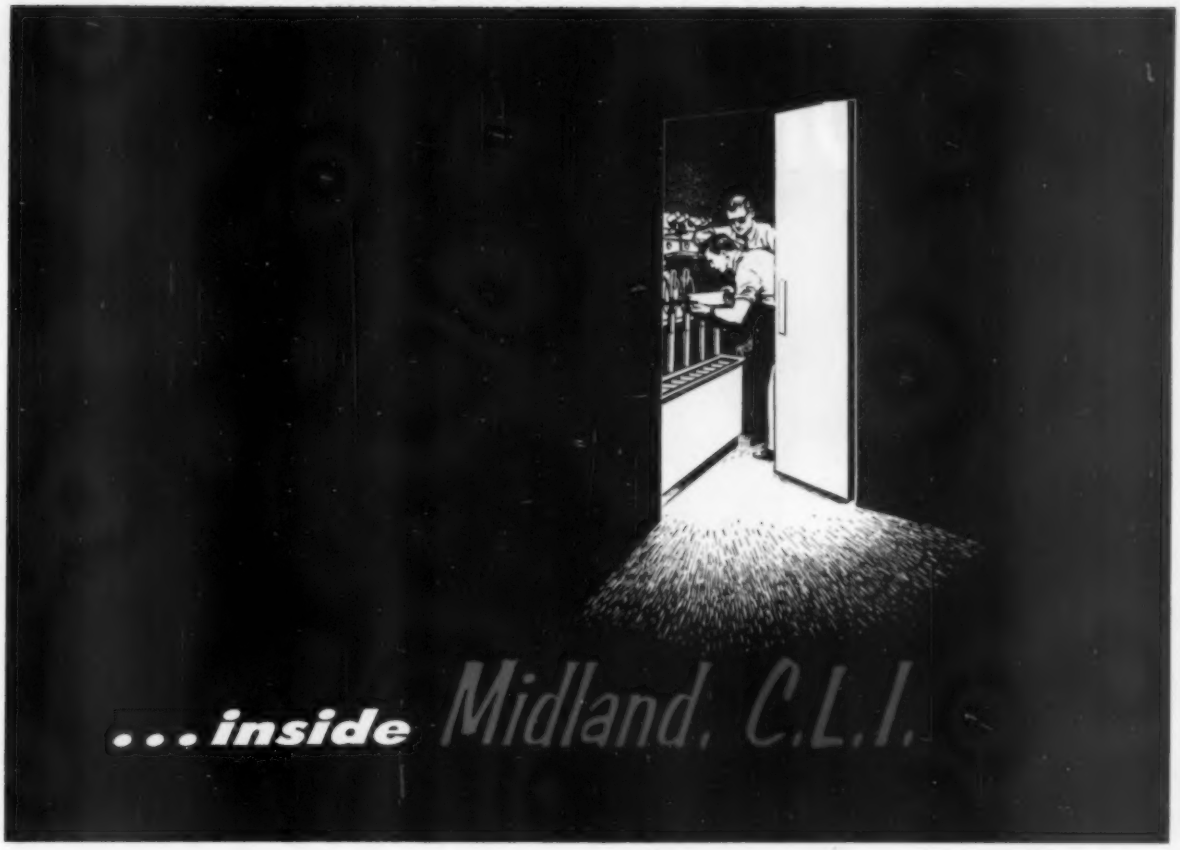
★ Phillips Petroleum et al No. 1 Sullivan, just north of Icy Bay, has been abandoned and a third test has begun. The plugged well is the second by the company and is located on a million-acre lease spread in the Katala area. The test was spudded nearly two years ago and was taken to a total depth of 10,013 ft. Result of five months testing has not yet been released, although the last zone was established at 2100 ft and 7-in. casing was set at 9000 ft. The third Phillips wildcat is located about ¼-mile south of the first Alaskan test and seven miles from the present abandonment. Kerr-McGee has the drilling contract.

ALABAMA

★ Extension of the Citronelle field, Mobile County, has been virtually assured at a test 2½ miles south of the field discovery well. The extender is Trans-Tex Drilling Company's No. 1 Boy Scouts of America. Results of a 50-ft core below 10,945 ft and tests which followed, have not been announced. A drillstem test made from 10,895 to 10,945 ft recovered 3000 ft water cushion and 2550 ft of 45 deg oil in 20 minutes. Flow was estimated at the rate of 30 to 35 bbl per hour. There are now five wells in the new field, three being produced by Gulf Refining and two by Zack Brooks, who brought in the discovery well.

CUBA

★ Siboney Development and Exploration Company has started drilling its first exploratory test well. Known as the Cacique G No. 1, it is located 16½ miles north of Santa Cruz del Sur on the southern coast of Camaguey province. Projected depth of the well is approximately 5000 ft and will test the Lower Cretaceous. Drilling is being done by the Simpson Drilling Company of Cuba. Siboney holds approximately 5,000,000 acres of Cuban concessions.



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Exploration

UTAH

★ The Texas Company has opened new wildcat oil production with the completion of a 55 barrel an hour well in San Juan County. Its No. 1-C Navajo, located about 10½ miles northeast of the Desert Creek field, flowed 430 bbl of oil on an 8-hour preliminary test through open 2-in. tubing. Perforations are at the 5828-5874 ft interval in the Basal Hermosa formation. Total depth is 5923 ft. Following the test, the well was shut in to await completion of storage tanks. Texaco has about 3000 acres under lease in the discovery area.

★ Gulf Oil has completed its Paradox zone discovery in the Coalbed Canyon unit in San Juan County. On test, the No. 1 Coalbed gaged 1,476,000 cu ft of gas and 6 bbl of condensate per day on choke. The pay zone was topped at 5667 ft, casing was set at 5830 ft and pipe perforated at 5762-5805 ft. The well has been shut in for lack of outlet.

TURKEY

★ Gilliland Oil Corporation of Los Angeles has been granted licenses for crude oil exploration covering 250,000 acres in Southeastern Turkey. The first well is expected to be spudded in approximately 60 days. One license of 125,000 acres is located on the southeastern shores of Iskenderon Gulf on the Mediterranean Sea. It includes 19 miles of shoreline and covers an anticlinal structure that is 12 miles long lying partially off shore. The second license area, known as the Rubaikale structure, is located near the Turkish town of Cizre, comprises 125,000 acres lying along the easterly side of the Tigris River, and is northerly and contiguous to the Iraqain and Syrian borderlines. It includes a surface anticline some 14 miles long. This structure is in the Iranian and Iraqian Basin area and lies on trend between Romindag and Garzandag fields of Turkey and the An Zahl and Kirkuk fields of Iran.

CALIFORNIA

★ The most significant oil discovery in California so far this year appears to be the General Petroleum Corporation's new deep zone discovery in the 35-year-old Santa Fe Springs field. The well, Santa Fe Springs 243, flowed 74 bbl per day of 30.9 deg oil the first hour through a 48/64-in. choke, with a tubing pressure of 350 psi. Completion depth was 9010 ft.

★ Bandini Petroleum Company is preparing to drill an offset to General Petroleum Corporation's new Santa Fe Springs discovery on its own property about 675 ft northeast of the find on Sec. 5, 3-11.

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Great Lakes Petroleum Services, Inc., this month takes its place in the highly-competitive wire-line services industry as doors open at the new plant shown above. Great Lakes will claim a place of leadership . . . leadership based on integrity, aggressive research, and a new dimension in service.

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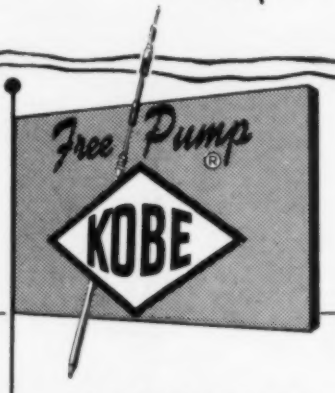

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COLORADO

★ In puzzling Weld County, H. C. Arnold, Utah Southern Oil and Arrowhead Drilling have started completion tests at their No. 2 McEndaffer, a discovery about 4 miles northwest of the Battle Canyon field. Crews drilled to 6392 ft, set pipe 2 ft off bottom, and perforated casing in the "J" sand at 6356-62 ft. On initial test the well flowed at the rate of 250 bbl per day through various chokes. Same operators are casing an offset to this discovery, following a drillstem test in which a full hole of oil was recovered.

MONTANA

★ Ohio Oil has started its No. 2 Government in an attempt to confirm the field discovery about two miles west. The No. 1 Government established commercial production in Carbon County. This well is shut in following completion test which flowed 176 bbl of 23 deg oil in 2¾ hours from the Red River formation at 8605-10 ft. It is about three miles west of the South Dakota line in the Williston Basin. The confirmation test is expected to go to 9200 ft or to the Winnipeg.

★ The British-American Oil Producing Company's No. 1 Montana State Well, located in Carbon County, ten miles north of the Elk Basin Oil Field in Wyoming, has been comoleted, flowing 338 bbl cf 54 deg crude and 1,000,000 cu ft of gas on a 24-hour test through an 18/64-in. choke. Total depth was 10,877 ft with present production from the Dakota sand through perforations from 8940 to 8950 ft. Previous tests had shown 56 ft of sand with good porosity and oil saturation from 8903 to 8959 ft. Plans are under way for the drilling of a confirmation well in the area.

★ Carter Oil Company has completed its No. 1 Horton, to extend the Wolf Springs field 2½ miles to the southeast in Yellowstone County. There are two producers in the area and three new tests are underway. The No. 1 Horton, with casing perforations in the Amsden formation at 6918-6212 ft, flowed 147 bbl of clean 29 deg oil a day on a 16/64-in. choke on completion tests. Carter has started the No. 2 Horton between the two major discovery areas.

FRANCE

★ Oil exploration licenses in the Isere Department of France, on the western edge of the Alps, have been granted to a newly formed company, Societe des Petroles de Valence, in which The British Petroleum Company has a 30 per cent holding through its prospecting subsidiary, D'Arcy Exploration Company. This is the first time British capital has been directly employed in the search for oil in France.

OREGON

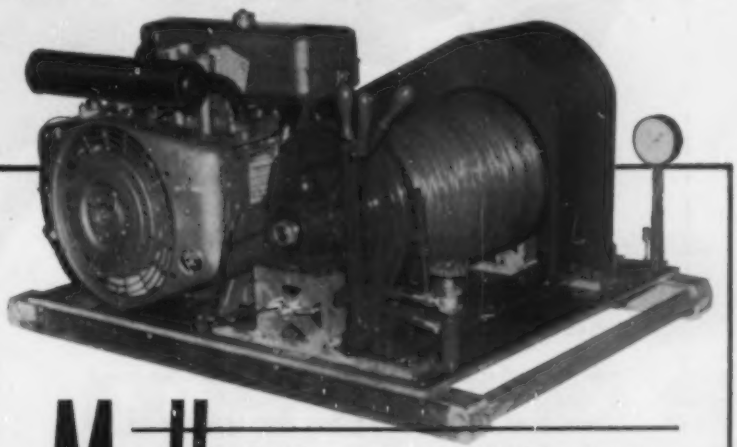
★ Sinclair Oil & Gas Company has abandoned its deep wildcat near Mapleton in Lane County. The well, Federal-Mapleton No. 1, reached a total depth of 12,800 ft, setting a new deep drilling record for the Pacific Northwest, but failed to find anything of commercial interest.

TANGANYIKA

★ Drilling of the test well on Mafia Island, off the coast of Tanganyika, by the D'Arcy Shell Petroleum Development Company of Tanganyika (a joint enterprise of The British Petroleum Company and the Royal Dutch Shell group) has been concluded. The well has been drilled to 11,051 ft and has yielded valuable geological information. The equipment will shortly be transferred to Zanzibar for the drilling of a second test well.

ILLINOIS

★ The Texas Company has established a new field in Jefferson County at its No. 1 M. E. Green. It was drilled to 3070 ft, plugged back and perforated in the Aux Vases zone at 2858-68 ft. The well pumped 150 bbl of oil per day on initial test. An offset has been staked on the same lease, 2 miles southeast of the Markham City field.



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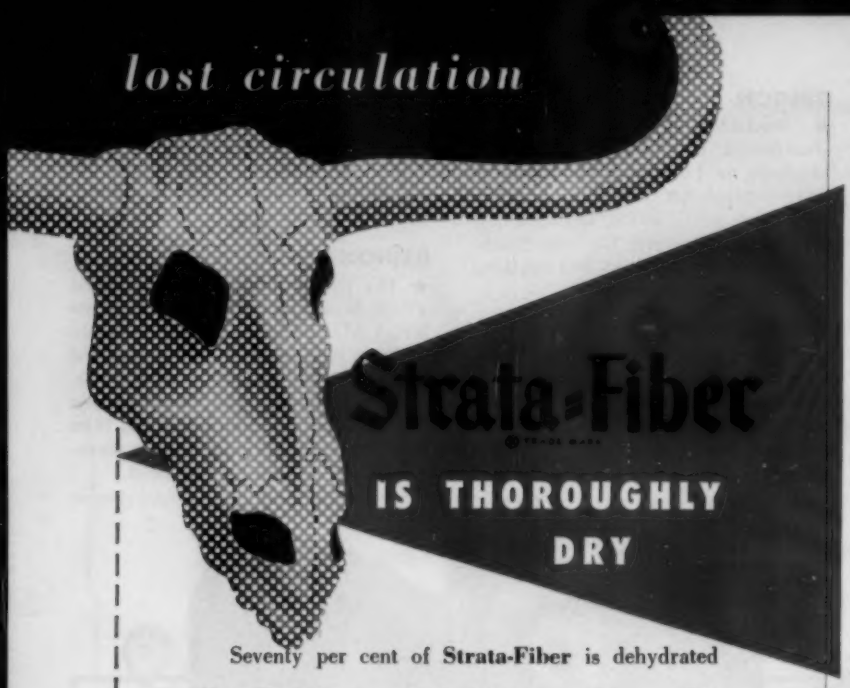
lost circulation



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Exploration

NEW MEXICO

★ The Gutman-Devonian No. 1 located in the Jal Area of Lea County, drilled by M. O. Rudman, Dallas, Texas, R. Olsen of Oklahoma City and Jal, and Sinclair Oil & Gas Company has been completed as a gas condensate producer. This was a stepout to the west to the Jal Devonian gas pool discovered last year. It was estimated by the operator, that he well had an open flow of 60,000,000 cu ft of gas per day with 25 bbl of condensate with each million cubic feet from 140 ft of perforations from 8450 to 8590 ft and with no water. Flowing pressure is constant at 2800 psi.

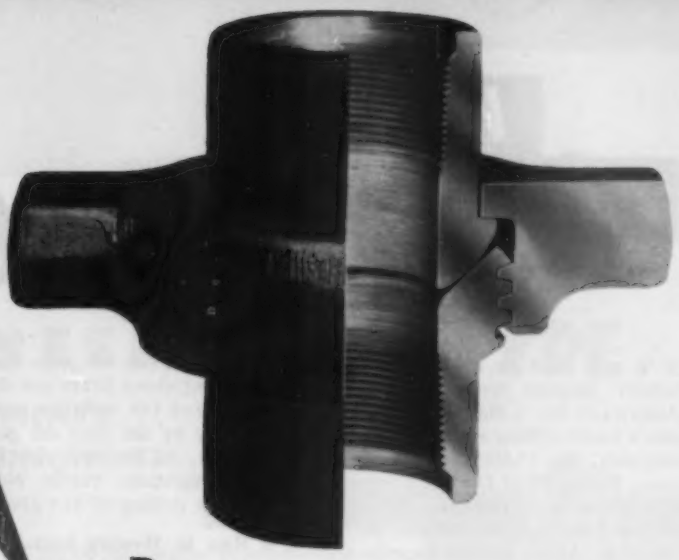
CANADA

★ Souris Valley Oil Company, Ltd., has successfully completed its Souris Valley-Pascar-Wardle No. 3-24. This well is located in the Daily Field West of Virden, Manitoba, and is the initial test on the half section recently acquired as a result of a Supreme Court decision. Swab results for twenty-one hours gave up 168 bbl of formation oil and 126 bbls of load oil, cutting less than 2 per cent BS&W. Total depth was 2500 ft with production casing set at 2498 ft. The well was perforated over an interval of 4-ft in the lower producing zone. Core analysis indicate two or three possible producing zones above the interval perforated. Further follow-up development wells are planned after production tests.

★ Union Oil Company of California has reported "a highly significant" discovery of oil near Loon Lake about 125 miles northeast of Peace River, Alberta, where its shallow wildcat Union Oil-Red Earth 12-17 flowed oil on three separate drillstem tests at the rate of 30 bbl an hour of 38 deg sweet crude without water.

The well hit the top of the granite wash at a depth of 4735 ft and top of porosity between 4740 and 4745 ft. In each test gas came to the surface in 7 minutes and the well began flowing sweet oil in 15 minutes and continuing flowing 30 bbl an hour until the test was terminated. Tests were made from intervals at 4740-4765 ft, 4762-4771 ft and 4770 to 4797 ft.

The discovery has started the biggest lease play in Canada in several years. The government has been swamped with applications totalling 8 or 9,000,000 acres. This is the first important strike in northeastern Alberta, and because of the quantity, light gravity oil and water-free 40-ft pay zone, it has drawn increased interest. Discovery area of this province is one of the few where large tracts of land are still plentiful. Union holds 100 per cent interest on a lease block of 700,000 acres near Loon Lake.



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HOUSTON, TEXAS

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What's doing in DRILLING

★ **A new slant on drilling** of Oklahoma's deepest producer, British-American's No. 2 Harrison, permitted much faster drilling and cut costs considerably. The 15,000-ft-plus well, put down by Big Chief Drilling Company, was drilled in the steep dip country of Beaver County in the southern part of the state. Actual surface location was spotted 1000 ft from the target area on bottom and the bit was allowed to follow the direction of the dip, thus eliminating dog-legs, slow drilling and other costly, time-consuming straight-hole expense. Pay was expected at 13,500 ft. Operators encountered a thrust fault, however, which resulted in hitting the Ordovician Bromide objective at 15,300 ft.

★ **Rotary drilling in New York** is underway by Fryer & Hanson Drilling Company, a Dallas, Texas, company. The firm, which already has several wells in Western Pennsylvania, will be entering an active new natural gas play centered in Cattaraugus County. Discovery well in the area was made by Felmont Oil Corporation, completed for 8,500,000 cu ft of gas per day from the Oriskany sand at a depth of 3750 ft.

★ **Israel bound drilling crews** of Rimrock Tidelands, Inc., Shreveport, Louisiana, will supervise all development work of the Matsada United Drilling Company, Ltd. in "the Promised Land." Rimrock plans to run six rigs for the company, which is the operating subsidiary for Lapidoth-Israel Petroleum Company, Ltd., which discovered the Heletz field.

★ **Wildcatting in Pakistan** is expected to get underway in June by Standard-Vacuum Oil Company, who has a 10,000 square mile concession in the western part of the country. Equipment is enroute to the first location in the Indus River Valley 10 miles north of Jedda in the Province of Sind. Contract for the test well has been given to Southeastern Asia Drilling Company.

★ **San Juan Basin drilling** has been stepped up by Pacific Northwest Pipeline Company, in efforts to meet the requirements of the company's new gas transmission line now being laid into the area. About 45 wells have been completed, about 30 are now drilling or testing, and 144 wells are expected to be ready by the time the gas line is complete. In the 10 years following line completion, Pacific Northwest plans the drilling of 814 gassers.

★ **Rigs in Western Canada** actually making hole number an even 200 as 1956 drilling programs get underway. Breakdown of the rigs by provinces places 6 rigs in British Columbia, 145 in Alberta, 39 in Saskatchewan, 9 in Manitoba and one in the Northwest Territories.

★ **Uranium discoveries of the future** will be made by oil companies while drilling for oil and gas, says a spokesman for the Ranger Uranium Exploration and Development Company. Use of such discoveries is as yet an unsolved problem, as mining shafts would be necessary to reclaim the rich mineral.

★ **California offshore prospects** will be scrutinized by engineers of Standard of California, although definite plans have not been announced. The company, very active in Gulf Coast waters, plans to spend nearly three-fourths of the year's $350,000,000 expenditure on exploration and development of existing oil properties. The organization's subsidiaries on the Gulf Coast now have daily production totalling about 30,000 bbl daily. Stancal has also planned sizeable investments for exploration and development in Canada, Trinidad, Venezuela and other Latin American countries.

★ **Huntington Beach offshore drilling** arrangements have been completed by Monterey Oil Company, Humble Oil and Refining, and Seaboard Oil. The group have been given permission by the California State Land Commission to conduct a core hole exploration program on a 1280 acre offshore lease. The companies plan to drill from a DeLong-type barge, capable of drilling in water depths up to 90 ft; it will be the first of its type used in California coastal waters.

★ **Wildcatting in Texas** looked good in January. Exploratory operations in the state slumped last year. The Railroad Commission reported that 1379 new wells have been completed this year, comparing with 1246 for the same period in 1955. Dry holes in the state already number 180; 100 of these were wildcat failures.

★ **Toklan Oil Corporation,** Tulsa, Oklahoma, is planning to drill about 100 wells this year. Company officials say most of the wells will be on proven acreage, although a number of wildcat prospects probably will be tested.

★ **"Safety on a Round Trip,"** a 16 mm color film with sound, has been released by the American Association of Oilwell Drilling Contractors. The 14-minute film portrays the necessary steps in bringing drill pipe out of the hole, as well as proper handling of slips, tongs and other rig equipment prior to lowering the pipe back down the hole.

★ **Universal Consolidated Oil Company** has completed its eighth producing well on the Twentieth Century-Fox Studio property in Beverly Hills, California. The well came in flowing 900 bbl per day of 32 deg oil and 850,000 cu ft of gas through a 16/64-in. choke from a depth of about 7725 ft. The company will immediately spud well No. 9 on the studio property and is also planning to explore residential town lot acreage which it also has under lease adjacent to and west of the studio property.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	Jan. 23	Jan. 30	Feb. 6	Feb. 13
Pacific Coast	130	130	133	127
Oklahoma	284	269	264	268
Kansas	181	175	155	166
Rocky Mountains	206	193	182	179
Canada	222	211	209	224
Ark-La-Tex	155	146	144	144
West Texas and New Mexico	492	487	480	496
Gulf Coast	648	608	644	612
Illinois	94	96	105	78
North Texas	367	352	320	325
	2779	2667	2636	2619

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

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WHATEVER YOUR REQUIREMENTS... THERE'S A WILSON RIG OF THE RIGHT SIZE AND TYPE FOR YOU!

DEPTH, SIZE or TYPE

Shown in the illustration is a new Wilson Giant Torcair drilling rig.

- The mast is Wilson's new Giant 126 foot portable drilling mast. It has a rated hook load capacity of 350,000 lbs. with 8 lines strung.
- One unique feature of this mast is that the ease of operation surpasses that of many smaller masts. Its erection is fully hydraulic, the same efficient system that is on the 96 foot Wilson production masts.
- The racking platform automatically folds out into working position at a desired height to accommodate the racking of trebles.
- The rig is a Wilson Giant Double Drum Torcair model powered by two WAKBU Waukesha engines with torque converters. It has an ample power capacity for efficient 8,000 foot work.

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Photograph at right shows the location of driller's controls, mounted on hinged "Y" base of the mast. Extreme lower left of photo shows hydraulic controls for raising and telescoping mast operations.

Driller is located to have the best position possible for full view of work at all time.

RUNNING TOUR with MEN in the INDUSTRY

J. E. Young

S. H. Oatway

John E. Young has been appointed administrative assistant to the vice president in Shell Oil Company's Pacific Coast area exploration and production office in Los Angeles, California. Young attended the University of Wyoming and George Washington University, graduating with a BA in business administration. He joined Shell in 1937 as a roustabout in Bakersfield, California. Just before his recent promotion, he served one year as a senior analyst in charge of salary administration for the personnel and industrial relations department.

E. W. Masters

E. W. Masters has retired as executive assistant to the Pacific Coast area vice president for Shell Oil after nearly 40 years in the oil industry, 30 years of which were spent with Shell. Masters, a Stanford University graduate, became associated with Shell in 1926 as a production engineer.

Stanley H. Oatway, assistant to the Pacific Coast area exploration and production vice president, has retired after 30 years' service with Shell. A native of England, Oatway began his employment with Shell in 1925.

R. S. McLaughlin has been appointed to the newly created post of export manager of Tide Water Associated Oil Company. Born and educated in Canada, McLaughlin joined Tide Water Associated Oil Company (Canada), Ltd. in 1933 as credit manager. For the past year he has been manager of the parent company's eastern division export department in New York City.

Stanley L. Hake has been appointed supervisor of the Midland, Texas, district for National Geophysical Company, Inc. Prior to joining National Geophysical, Hake served five years as supervisor in Midland district for a contract exploration company.

George W. Dawson has been employed by Plymouth Oil Company as chief petroleum engineer at the company's headquarters in Sinton, Texas. Dawson recently resigned as chief petroleum engineer of the Kuwait Oil Company, Ltd., in Ahmadi, Kuwait, a position he had held since 1953.

H. C. Slider has been appointed associate professor in Ohio State University's department of mining and petroleum engineering. Slider formerly was Illinois division reservoir engineer for the Shell Oil Company, Centralia, Illinois.

Roy Iles, business and civic leader of Vernon, Texas, has been elected chairman of the board and executive head of the Seaboard Oil and Gas Company. Iles was instrumental in Seaboard's recent acquisition of the Socorro Uranium Corporation of New Mexico and the Equitable Uranium Corporation of Colorado. Iles will continue as chairman of the board of the Socorro Uranium Corporation.

Hal R. Adams has been promoted from division geophysicist to division exploration manager, Northwest division for Sohio Petroleum Company's production department. Adams was first employed by Sohio in 1950 in Regina, Saskatchewan, as chief geophysicist, Canada.

W. A. Scott of Shell Oil Company has been elected chairman of the Billings, Montana, Petroleum Section, American Institute of Mining and Petroleum Engineers, for the year 1956. **H. E. Allen** of The Carter Oil Company is a new director. **Charles F. Hunkins** of Northern Pacific Railway's oil development department, retiring chairman, also becomes a director.

Cecil E. Brandon, field superintendent at Sterling, Colorado, has been appointed district superintendent of The British-American Oil Producing Company's southwestern district, with headquarters at Midland, Texas. He will be replacing **Paul A. Kindsvater.** He began his career with British-American in 1949 as a trainee roustabout during summer vacations while attending Oklahoma University. **Richard E. Steinhorst** has been named field superintendent for British-American's Denver-Julesburg Basin field. Steinhorst is transferring from the company's head office in Dallas, Texas, to his new headquarters in Sterling, Colorado, replacing Brandon.

Ralph L. Cormany has joined the staff of Hancock Oil Company as manager of the land department. Cormany formerly occupied the position of landman and chief contract agent for the southern district of the Standard Oil Company of California.

Grant H. Young, assistant to the president of The Ohio Oil Company since 1954, has been appointed manager of the newly created marketing development division. He will take the new position after completing the advanced management program at Harvard University. **R. M. Churchwell,** assistant chief petroleum engineer, was named to succeed Young. **L. P. Foote,** senior petroleum engineer, succeeds Churchwell. Young first worked for Ohio Oil in 1930. Churchwell joined Ohio Oil in 1941 as a draftsman in the Casper, Wyoming, production division office.

I. L. (Steve) Schooler has been promoted to chief clerk for the drilling department of the Morgan City, Louisiana, office of Kerr-McGee Oil Industries, Inc. Moving up to Schooler's former position as materials control chief in the company's headquarters in Oklahoma City, Oklahoma, is **George Ruster,** formerly assistant to Schooler. The position to which Schooler is being advanced is a newly created one.

R. L. Lay, assistant to the vice president in charge of the Texas Company's producing department — domestic, has been appointed assistant to the vice president in charge of foreign operations — Eastern Hemisphere. **J. H. Rambin Jr.,** assistant general manager of the producing department — domestic, with headquarters at Houston, Texas, has been appointed assistant to the vice president in charge of the producing department — domestic, with headquarters in New York City. **W. N. Holt,** assistant to the vice president in charge of the foreign operations department — Eastern Hemisphere, has been assigned executive duties for the company in London, England, where he will serve as a director as well as vice president of The Texas Company (Iran), Ltd. In addition to other duties, he will also serve as deputy shareholder's representative in London. Lay began work with Texaco at Houston in 1932 in the geophysical division of the producing department. Rambin was first employed by Texaco in 1935 as a roustabout. Holt began service with The Texas Company in 1937 as a trainee at Port Arthur, Texas.

Homer O. Woodruff has been promoted from assistant division manager of the Pacific Coast division of The Texas Company to assistant general manager of the company's producing department and transferred to Houston, Texas. He began work with Texaco in 1933 as a roustabout at Santa Paula, California.

Douglas R. Keenan Jr. has joined the staff of Gulf Coast Leaseholds, Inc., as exploitation geologist. He was formerly a senior geologist on the staff of Sinclair's Gulf Coast division. Keenan has specialized in reservoir and reserve geological work.

Joseph E. Holm, manager of The Atlantic Refining Company's Oklahoma-Kansas crude producing region, has retired after 44 years of service with the company. In 1917, he was sent to Oklahoma as Atlantic's first representative for producing in the Southwest. Holm will be succeeded by **Louis F. Davis,** formerly assistant manager of the Oklahoma-Kansas region. Davis joined Atlantic as a pumper in 1935.

Louis G. Chombart will henceforth conduct his professional activities as a well log consulting engineer on a completely independent basis, with headquarters in Wichita, Kansas. He has resigned from Amstutz and Yates, Inc., with whom he had been associated for the past five years. Previously he was associated with Dr. R. G. Hamilton of Tulsa, Oklahoma, and was with Schlumberger Well Surveying Corporation for 14 years, his last position with that company being manager of its Kansas division. One of his first projects as an independent consultant is to be a four-month assignment for the Institut Francais du Petrole (French Petroleum Institute) of Paris, France, through June.

L. G. Chombart

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McCullough Log Enables Precision Perforating of 5′ Pay Zone

Discovers 8′ Error in Electric Log and Casing Measurements

Operator of this old well ran an electric log which located a new, possibly productive, 5′ sand.

McCullough was then called to run a Neutron Log. The Neutron curve confirmed the productive possibilities of the new zone, but also discovered that both the electric log and casing measurements were 8′ in error.

The well was plugged back to 6800′ and perforated according to McCullough measurements.

Thirty ½" improved Ogival Bullets were shot in the 5′ sand in one run by a 3½" O.D. McCullough M-3 Gun. Casing was 5½" O.D. 17 lb.

The well started flowing through the casing before the M-3 Gun was out of the hole.

If the McCullough Radiation Well Logger had not discovered the 8′ measurement error, the 30 shots would have missed the pay zone entirely.

It always pays to rely on the accuracy and dependability of McCullough's Radiation Well Logger.

McCullough Log Locates and Defines 11 New Pay Zones

Accuracy of McCullough Radiation Well Logger Permits Sharp Shooting of 11 Thin Zones for 138 B/D Increased Production

This was an old well in an established California oil field. Production had fallen to five barrels of oil per day.

Believing better production was possible, the operator decided to log and re-perforate the well. McCullough's combination Gamma Ray-Neutron Log was run from 4380′ to 5645′, locating several small, promising stringers of untried sands above the original pay zones.

A simultaneous collar log accurately located casing collars in relation to these thin sands, thus assuring "pin-point" accuracy in perforating.

The two original producing sands were re-shot, four holes per foot, with 26 improved ½" Ogival Bullets from McCullough M-3 Guns and with 26 McCullough Standard Casing Glass Jets.

Above these zones were the 11 small sand stringers ranging in thickness from 4 feet to 13 feet. Intermediate zones, lying between the productive sands, which were not to be perforated ranged in thickness from 5 feet to 103 feet.

Accurate measurement means "putting the shots where they count"... and the "pin-point" accuracy of the McCullough Radiation Well Logger makes sharp shooting of thin zones practical... assures uniform perforating coverage of any zone, thick or thin.

The 11 pay sands were perforated with 256 shots, four holes per foot, by 3½" O.D. McCullough M-3 Perforators firing ½" Ogival Bullets. Production increased from 5 to 143 barrels of oil per day.

This is only one of many actual jobs where the accurate, reliable, easily interpreted information provided by the McCullough Radiation Well Logger has located and defined multiple pay zones, tied-in casing collar locations and permitted precision perforating for best possible production.

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LOS ANGELES
HOUSTON
EDMONTON

Personals

Robert B. Bossler has been named professor of petroleum engineering at Texas A&M College. He will devote his principal attention to petroleum engineering courses in valuation and secondary recovery. As a member of the U. S. Treasury Department staff in Washington, D. C., he helped prepare the Treasury's first manual for the oil and gas industry, contributing procedures to enable the government to estimate recoverable oil reserves for depletion purposes. Bossler was once an independent operator and is a former vice president of the Brundred Oil Corporation.

In 1954, he was named the director of the Pennsylvania Grade Crude Oil Association, Bradford, Pennsylvania, which is a research organization directed to prolonging the life of oil fields by improving recovery methods.

W. E. Martin has been named public relations representative for the New Orleans, Louisiana, exploration and production area and marketing division of Shell Oil. He succeeds **R. G. Pearson,** who has been transferred to the New York head office. Martin was formerly public relations representative in the Tulsa, Oklahoma, area. He began work with Shell in 1938 at the Wilmington, California, refinery.

Paul R. Warren, Oklahoma City, Oklahoma, has been promoted to regional geologist for Continental's central region. Formerly assistant regional geologist, Warren will continue to make his headquarters in Oklahoma City. He succeeds **C. L. Arnett,** who has retired. Warren, who joined Conoco in 1933 as a geophysicist, received his master's degree from Oklahoma A&M College, where he majored in electrical engineering. Arnett became associated with Continental at Ponca City, Oklahoma, in 1932. He was graduated from the University of Oklahoma.

Orville L. Fisher, since 1952 general manager of Continental Oil Company's southern region, has been elected a vice president of Continental. He will continue to make his headquarters in Houston and to manage Conoco's southern region. Fisher has been associated with Conoco for nearly 30 years.

O. L. Fisher

G. Dewey Thomas has been made area geologist in Shell's New Orleans exploration and production area after having been geologist for special problems in the Shreveport, Louisiana, exploration division. He succeeds **James B. Dorr,** who has been given a special assignment in the area office. Thomas joined Shell as an assistant geologist at Shreveport 31 years ago. He was graduated from the Colorado School of Mines.

Chester L. Wheless and **Pierre M. Aubuchon** have announced the formation of Wheless and Aubuchon, a consulting petroleum and natural gas engineering firm, in Austin, Texas. The firm will specialize in evaluation, management, proration, and unitization of oil and gas properties. Wheless is resigning from the position of chief petroleum engineer of La Gloria Oil and Gas Company, Corpus Christi, Texas, after 15 years employment with that company. Aubuchon was formerly employed by La Gloria.

J. Randolph Buck and George Y. McCoy have announced the formation of a partnership in the petroleum engineering consulting firm of McCoy and Buck, with offices in Dallas, Texas. McCoy, a former faculty member in the department of petroleum engineering at Texas University, has been in consulting practice in Dallas since 1948 except for one year with International Oil Corporation, which he left as president. Academic studies were at Oklahoma A&M, Colorado School of Mines, Kansas University and Texas University. Field experiences include exploitation engineering division, Shell Oil Company; reserves and income tax unit, Skelly Oil Company, and valuations for oil loan department, Republic National Bank, Dallas. Buck has been a consultant in Dallas since 1954, specializing in valuations, waterfloods and general reservoir technology. He was formerly associated with DeGolyer & McNaughton as a reservoir engineer. Previous experience includes service with Magnolia Petroleum Company as senior research engineer and with The Texas Company in Louisiana following graduation from Worcester Polytechnic Institute, Worchester, Mass. in 1938.

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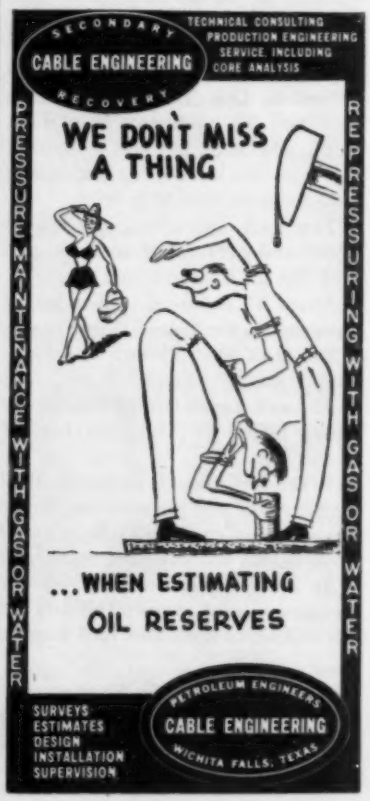

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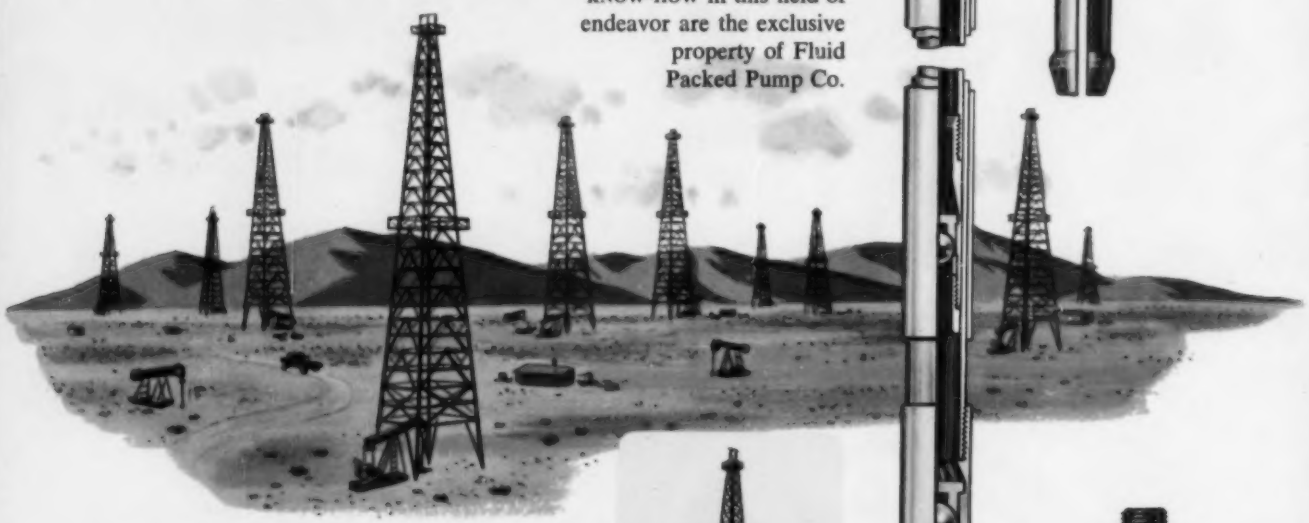

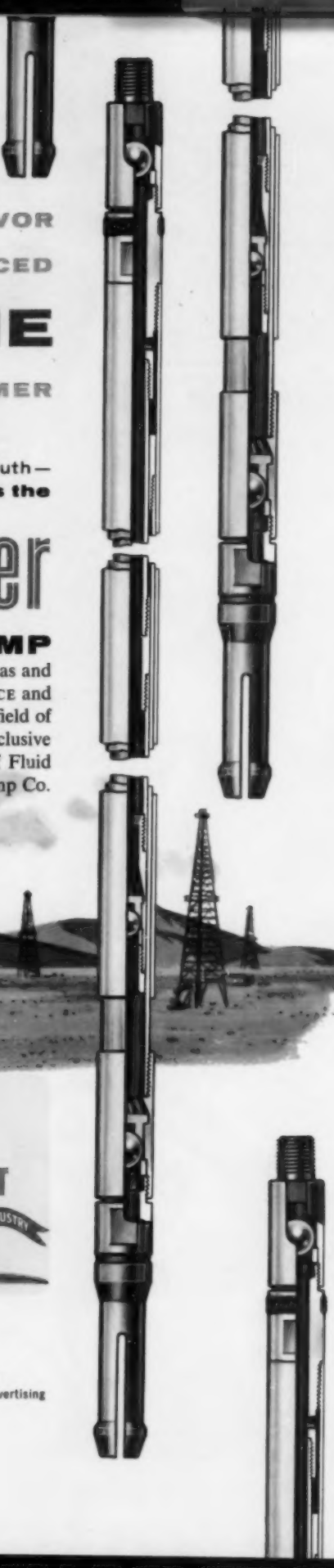

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Any qualified mud engineer can use Seeco-Mul without extra equipment or special instructions. Just add it to the system (usually 2 to 3 lbs./Bbl.) through the hopper or the mud hog suction over one or two circulations. Seeco-Mul is packaged in sturdy, moisture-proof 50-pound sacks that are easy to handle around the rig.

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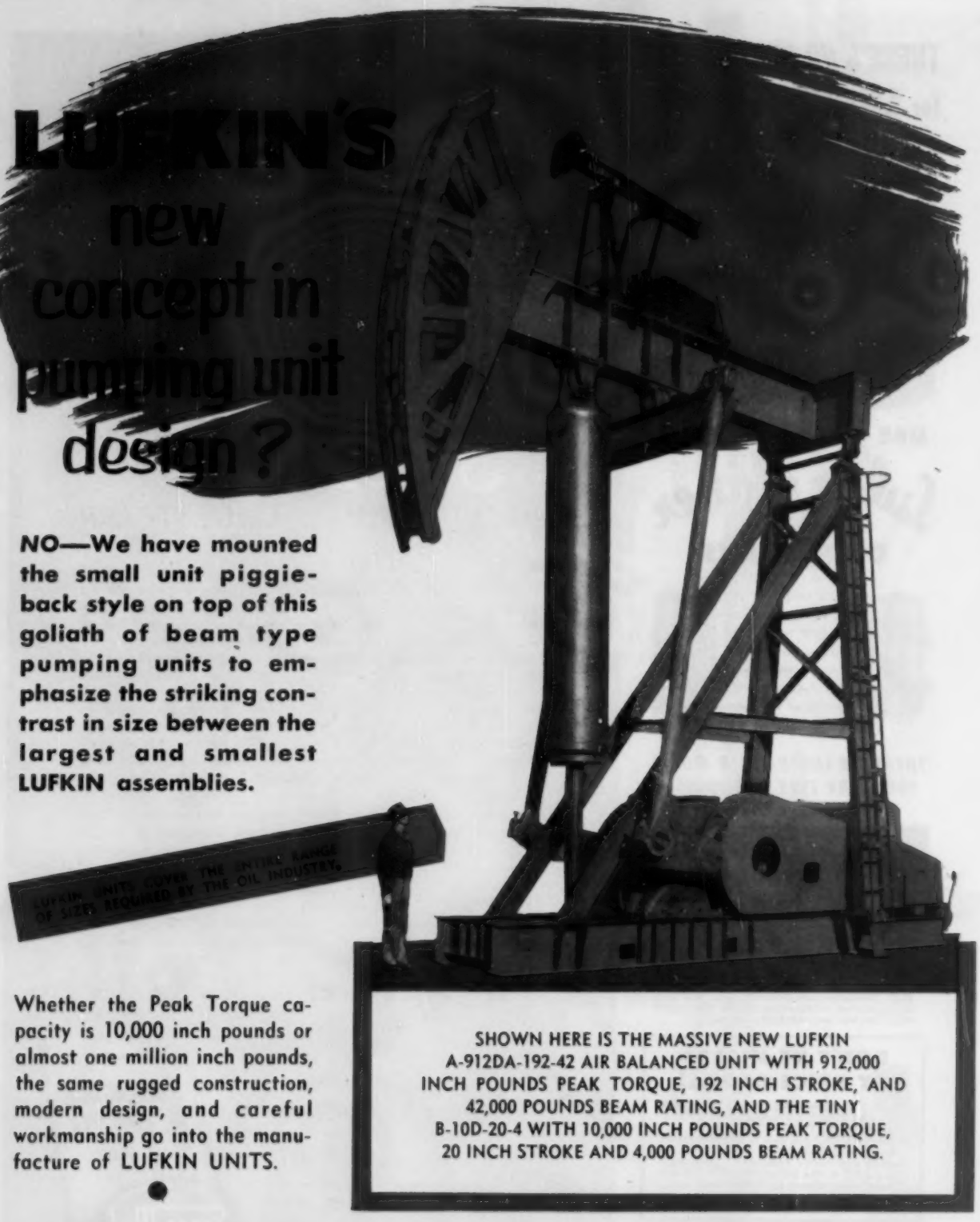

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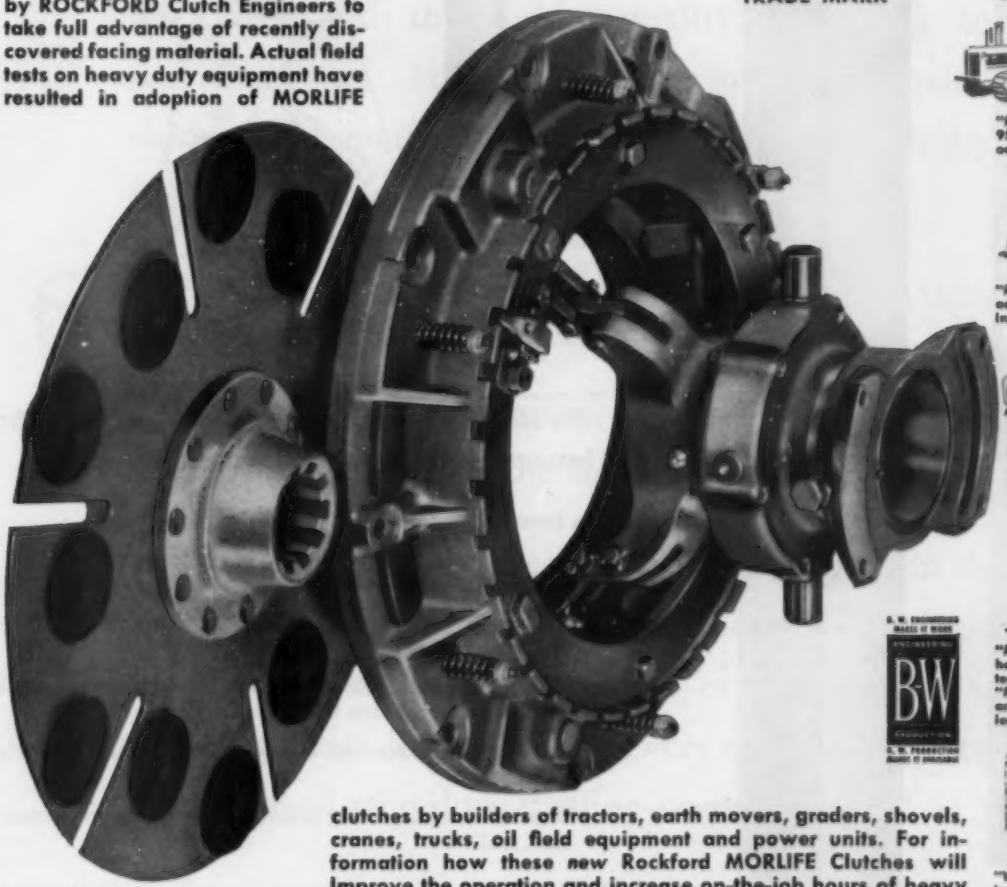

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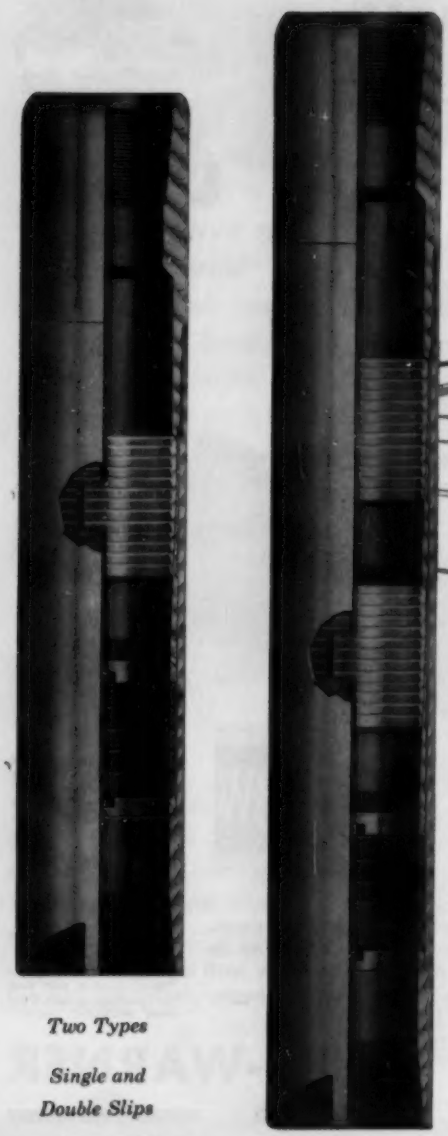
For safe, economical, pressure-tight casing repairs

The ideal tool to repair damaged or split casing in the well because of its ease of operation and efficiency.



Two Types

Single and Double Slips

Here's how —

- Cut casing below defective area and remove from well.
- Replace defective portion and attach Casing Bowl to the bottom of the replacement string.
- Run casing back until casing standing in the well "shoulders" inside the bowl.
- Pull up to set slips and expand packing—and the job's done.
- Segmented lead packing assures a pressure-tight, permanent seal.

With this tool the cement job around the casing is not disturbed —nor is the inside diameter of the casing string reduced. Tools that pass through the casing will also pass through the Bowl.

BAASH-ROSS TOOL COMPANY

DIVISION OF JOY MANUFACTURING COMPANY

Los Angeles, Calif. • Houston, Texas • Odessa, Texas • Oklahoma City, Okla. • Casper, Wyo. • Olney, Ill. • Edmonton, Alb., Canada • New York City

An Announcement of Importance to Customers and Prospects of CARDWELL

Throughout the years the CARDWELL name has been associated with the highest quality in drilling and servicing rigs. This reputation has been gained through the meticulous attention to detail in design, metallurgy, and workmanship.

The recent purchase of the CARDWELL organization by JOHN W. MECOM is a step toward even higher quality, even more advanced design, and even better service in the future.

With substantially greater resources, and with the availability of a drilling organization to test new designs, the industry can expect even finer rigs in the future—rigs incorporating every modern advancement proved to reduce drilling costs.

Cardwell Manufacturing Company

P. O. BOX 2001, WICHITA, KANSAS

DRILLING RATE 36.2% FASTER WITH NO-GLO OIL

Drillers and Geologists fully approve of non-fluorescent emulsion mud

Now your exploratory drilling can benefit from the faster drilling rate and other advantages of emulsion mud, with no effect on ultra-violet core and cuttings examination. Here's the first and only drilling fluid that provides the benefits of an oil-in-water emulsion, yet does not fluoresce and does not impart false "cut" or color to samples obtained under any drilling conditions, including high temperatures and long aging of fluid.

In a recent field test* in a commercial well, the drilling rate increased from an average of 4.47 feet per hour to an average of 6.09 feet after addition of No-Glo Oil to the mud system. This was an average increase of 1.62 feet per hour, or 36.2% faster drilling.

Many specific advantages of No-Glo Oil contribute to this drilling rate increase. No-Glo Oil in the mud reduces torque, slicks up the hole, minimizes sticking pipe, cuts down fluid loss and dangerous wetting of hydratable formations, lessens almost any kind of down-hole trouble you can think of.

Prior to No-Glo Oil, emulsion drilling fluids that penetrated cores and cuttings would fluoresce under black light indistinguishably from crude oil, especially after exposure to bottom hole temperatures. Core analysts and petroleum geologists objected to oil emulsion muds despite the improved drilling performance. Now everybody's happy—driller and geologist alike fully approve of No-Glo Oil.

To take advantage of No-Glo's benefits, OBI recommends it to be used with White Magic, the superior emulsifier which, unlike most emulsifiers, is non-fluorescent... also with No-Glo Thread Lubricant, the high-stability non-fluorescent tool joint and drill collar dope that doesn't build up. Make good use of all three in your present wildcat drilling program. Get all the benefits of emulsion-mud drilling while keeping the hole completely free from fluorescence.

Then you can drill a faster, cleaner hole and still be sure that every glow under the black light, every "cut" in the test solvent, means crude oil in the formation.

*Details on request.

OIL BASE, INC.

WIN $100.00!

A cash prize of $100 will be awarded for the best one page letter entitled "Where we should have used No-Glo Oil... and didn't." All entries should be postmarked before midnight, March 1, 1956, and will become property of Oil Base, Inc. Decision of judges will be final. Ask your OBI representative about further details or mail entry to Oil Base, Inc., 130 Oris St., Compton, Calif.

PLANTS IN: Houston • Odessa • Duncan • Compton

BRANCHES IN: Houston • Odessa • Corpus Christi • Oklahoma City • Duncan • Lafayette • Harvey • Bakersfield • Long Beach • Ventura Mexico City • Caracas • Lima • Bogota • Calgary • Paris. CABLE ADDRESS: OBI

B-152

VALUES TO LOOK FOR IN 2-WAY RADIO...

Look for the

Red Head

NEW, CLEAR TALKING, MOBILE MICROPHONE OFFERED YOU FOR RCA 2-WAY RADIO

Improved Fidelity. Better voice quality than ever before.

Easy to grasp and hold. Designed to fit the hand . . . left or right, small or large, bare or gloved. Slip-proof grip.

Easy to use. Positive-action bar switch is of ample length, sturdy and convenient.

Easy to hang. Clips easily into metal hanger, as standard equipment. Rubber cup holder also available, if desired.

Easy to service. Case design assures easy access, simplifies servicing.

Distinctive appearance. Plexiglas mouthpiece, rimmed with aluminum.

Built to last. High-impact Bakelite, guaranteed against breakage for 5 years. Switch, with self-wiping contacts, stands up in all kinds of weather.

Your communications system is only as efficient, in saving time and earning profits, as its components. Look for these marks of quality found in RCA 2-Way Radio: Superior crystals and tubes for clearer talking, longer operation . . . heavy-gauge steel case for rugged service . . . advanced engineering for greatest satisfaction . . . color-coded tuning for simplest maintenance.

"Mark of Quality"

RCA

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Radio Corporation of America,
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☐ Please send me complete information on the use of 2-Way Radio in . . . .

. . . . . .

☐ Have RCA Communications Specialist make a free RADIO SURVEY of my business.

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GREATEST COST REDUCING FACTOR IN WELL DRILLING TODAY!

BURNS LEAD SEAL

Safety CASING HANGERS

1. SIMPLIFIED, STREAMLINED DESIGN. NO DRAG SPRINGS. FEW PARTS PROMOTES GREATER STRENGTH AND EFFICIENCY.
2. LEAD SEAL BELOW SLIPS WILL NOT SET GOING IN HOLE. WON'T BULLDOG ON RETRIEVING.

Years ago we set out to cut the high costs of oil well drilling, not just in theory but in practice; not just in pennies but in thousands of dollars. The wasteful overlapping of casing and how to eliminate it took our eye so we set out to whip it. RESULT: Today you find Burns Casing Hangers all over the world saving millions of dollars in casing cost and make-up time.

With the Burns Hanger you suspend the casing in tension—casing won't sink in the formation, buckle or bend into cavities. Slips bite sharply into the casing at the setting depth and stay there—100% full bearing slips instead of the old 2 point cone type prevents slip breakage. Lead seal below the slips won't set going in the hole—won't jam the slips upon retrieving. Weight of the oil string compresses the lead seal on setting, forming a perfect and permanent lock to the casing—no safer method has ever been devised.

Thousands of Burns Hangers are now in use in every field, at every depth; by independents and majors alike. We're extremely proud of the Burns line of hangers and only now after years of successful field experience are we beginning to broadcast this story through world-wide media.

Burns Hangers are available in all popular sizes. Prices upon request. Please give size, weight and the thread connection of oil string, and also size and weight of casing in which you set hanger. Check with us direct or consult a Burns Distributor.

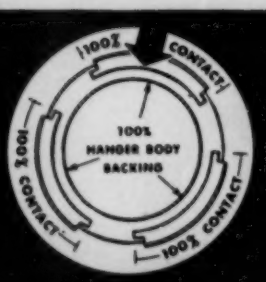
BURNS TOOL CO.

8436 Salt Lake Avenue Bell, California

DISTRIBUTORS:

M. D. Rehders
Post Office Box 396
Farmington, New Mexico
Telephone Davis 5-3922

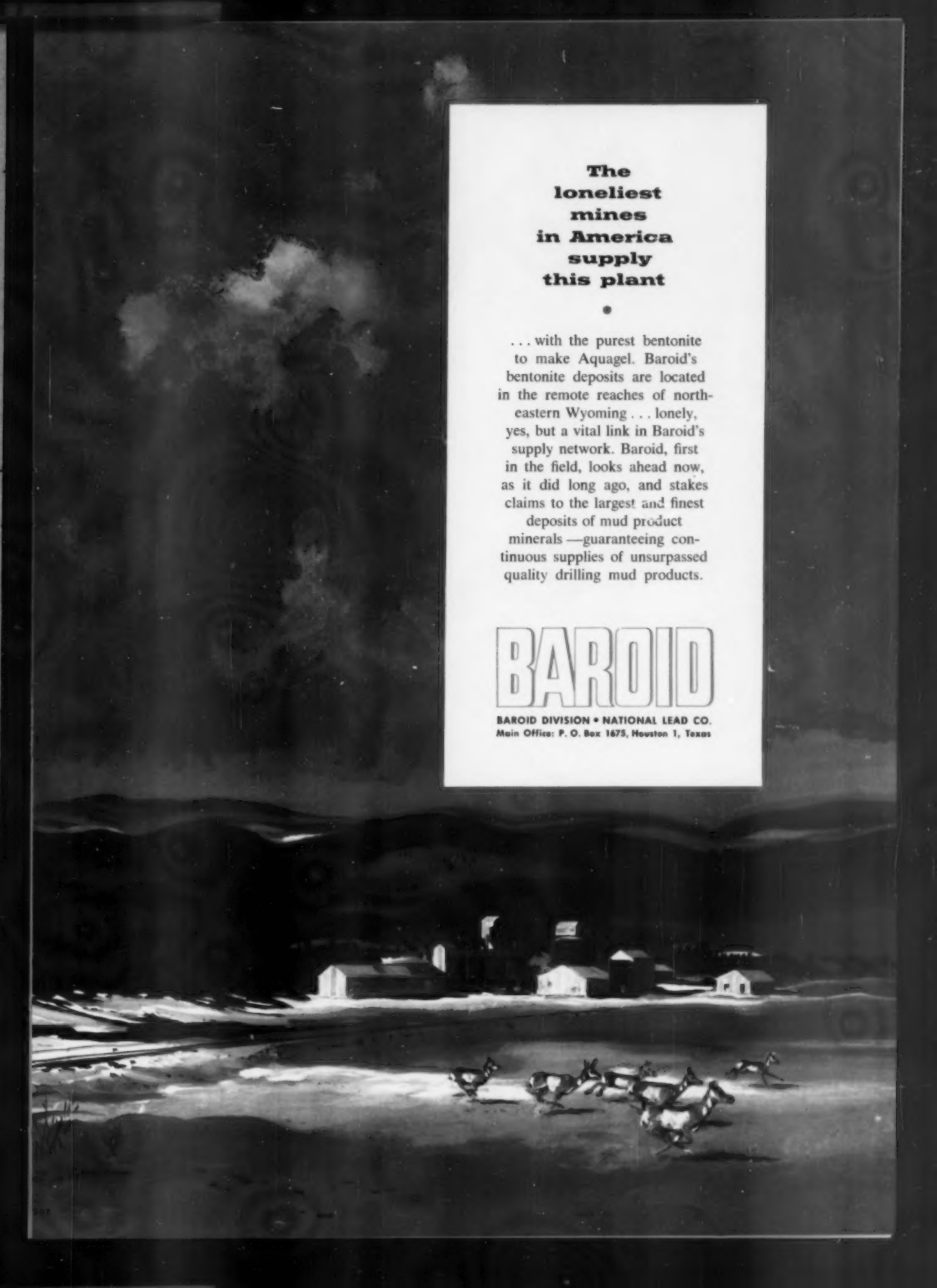
Thorson Oil Tools Ltd.
7106 103rd Street
Edmonton, Alberta, Canada
Telephone 393-838



LOOK BEHIND THE SLIPS

Specialized Construction provides each slip with 100% hanger body support throughout the entire length of slip travel—no cracked or broken slips—positive operation—all the area of each slip securely grips the casing.

1. BURNS LEAD SEAL CASING HANGER *with hold down slips. Slips set automatically after casing is suspended.*
2. BURNS CIRCULATING TYPE CASING HANGER *with lead seal pack off. On cementing jobs this hanger assures easier circulation around the hanger and a positive seal after cementing.*
3. BURNS DELAYED ACTION LEAD SEAL PACK OFF CASING HANGER. *Same features as the Burns circulating type except the by-pass ports are eliminated. You can hang your oil string, circulate, and cement before closing the lead seal packing element.*


The
loneliest
mines
in America
supply
this plant
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. . . with the purest bentonite to make Aquagel. Baroid's bentonite deposits are located in the remote reaches of northeastern Wyoming . . . lonely, yes, but a vital link in Baroid's supply network. Baroid, first in the field, looks ahead now, as it did long ago, and stakes claims to the largest and finest deposits of mud product minerals —guaranteeing continuous supplies of unsurpassed quality drilling mud products.
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USE *MONEY-SAVING

Man-Tan

*It's like drilling every fifth well with no cost for mud chemicals!

EVERYWHERE MAN-TAN is being used it is reducing drilling mud costs. It can save you 20% or more on your chemical costs – that is the same as free chemicals on every fifth well!

In field after field, drillers and mud engineers are thinning their mud with MAN-TAN instead of quebracho or other expensive thinners. MAN-TAN actually costs less per bag than other tannin-type thinners and does the same work.

Baroid was first to produce *efficient* mud products. Baroid is first to offer new products that *cut mud costs*. You are losing money if your drilling crews are not using MAN-TAN now.

MAN-TAN, like other tannates, is mixed with caustic soda to secure the alkaline-tannate compound that thins drilling mud.

Start using MAN-TAN now – wherever you would use quebracho or other tannin-type thinners. Write for technical bulletin or contact your Baroid Engineer.

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Please send me the latest technical literature on Man-Tan.

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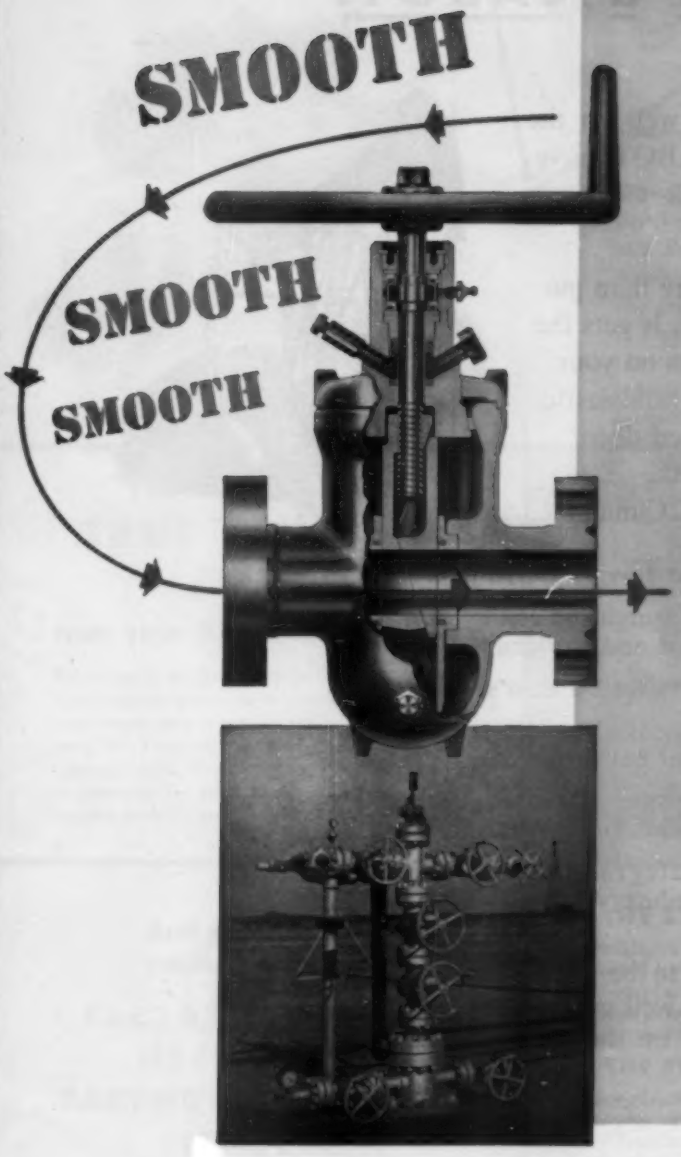
Best Choice...

...for NOW and the FUTURE



W-K-M Valves

The fluid flow through a W-K-M-Valve approaches true laminar flow even more closely than the flow through a smooth wall pipe. There is no place for sediment to collect.

The complete story of this quality valve includes also the following features:

- **PARALLEL EXPANDING GATE**
  ... seals on both sides by expansion, not by wedging or jamming.
- **OVERSIZE, RENEWABLE SEATS**
  ... not exposed in either open or closed position.
- **LUBRICATION**
  ... for all moving parts from supply in the body where it prevents internal corrosion.
- **PRESSURE SEAL BONNET**
  ... uses no studs and nuts — self-adjusts to temperature changes — seals tighter as pressure increases.
- **METAL-TO-METAL SEALS THROUGHOUT**
  ... no "O" rings, rubber, fiber or synthetic materials.

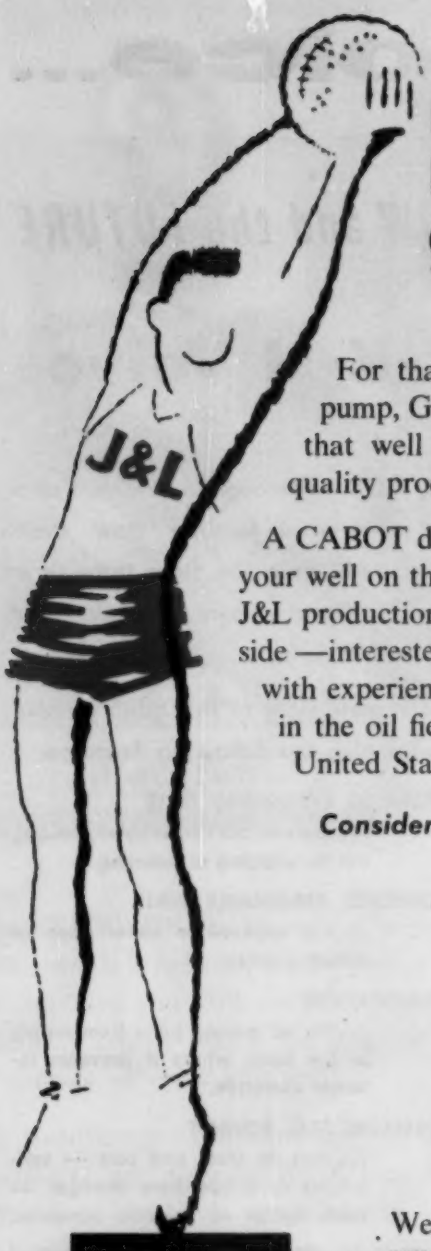
W-K-M Valves

W-K-M Manufacturing Company, Inc.

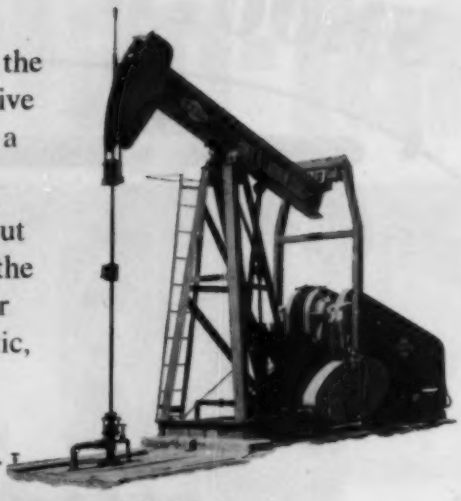
A subsidiary of ACF Industries Incorporated

P. O. Box 2117, Houston 1, Texas Los Angeles, California

Export Office: 45 Rockefeller Plaza, New York, N. Y.



PUT J&L ON YOUR PRODUCTION TEAM!
Get a CABOT!



For that next well on the pump, Get a CABOT. Give that well a break using a quality product.

A CABOT does more than put your well on the beam. It gets the J&L production experts on your side —interested and enthusiastic, with experience rooted deep in the oil fields of the United States and Canada.

Consider only a few important FACTS:

1. Unsurpassed quality of material and workmanship.
2. Unexcelled field service.
3. Equalastic (patented) rubber tail bearing.
4. Simple, effective adjustable crank counter balances.
5. Integral low-shaft-center reducers (no oil seals).

We want to be there with a CABOT when your next well goes on the pump — get your J&L store on the telephone now.

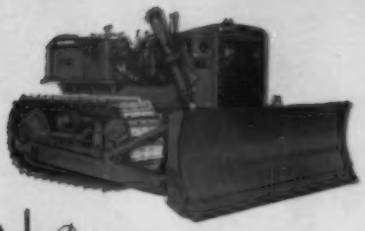
J&L STEEL

Jones & Laughlin

SUPPLY DIVISION – Tulsa

SERVING THE UNITED STATES AND CANADA

4-M



ALLIS-CHALMERS OIL FIELD EQUIPMENT

SOLD but not forgotten

by your Allis-Chalmers dealer

When you invest in Allis-Chalmers equipment, you are getting far more than just a modern machine. Your dealer offers you the opportunity to do a better job at lower cost. He wants your equipment to give A-1 performance day in and day out. His reputation depends on it.

That's why your Allis-Chalmers dealer puts so much importance on good preventive maintenance practices . . . encourages you to take full advantage of his modern servicing facilities.

You're always sure of

TRUE ORIGINAL PARTS

from your Allis-Chalmers dealer

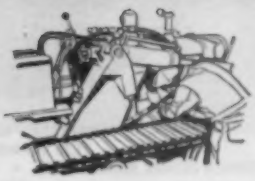
Parts made in the same factory, to the same rigid specifications as original equipment, are your assurance of getting top performance and long life. Treated, packaged and sealed against rust and dust, True Original Parts are stocked in quantity by each dealer to give you quick service close to your job.

And you can have confidence in his

FACTORY-TRAINED MECHANICS, FACTORY-APPROVED METHODS

IN THE SHOP

Specialized facilities include factory-approved tools and all necessary equipment for complete service. Factory-approved methods are used to save you time and money, assure finest workmanship.



IN THE FIELD

Factory-trained servicemen are ready to help you, day or night. Their technical know-how and practical experience get the job finished fast . . . at lowest possible cost to you.

You can depend on your Allis-Chalmers dealer

ALLIS-CHALMERS, CONSTRUCTION MACHINERY DIVISION, MILWAUKEE 1, WISCONSIN

ALLIS-CHALMERS

It takes a certain kind of specialist...

With experience to know the proper application of drilling structures.

Lee C. Moore design-engineers provide much of the "Know How" to apply the right Lee C. Moore structure to each type of drilling problem. Their years of experience provide a "strong link" in the progressive service that justifies the utmost confidence and dependability.

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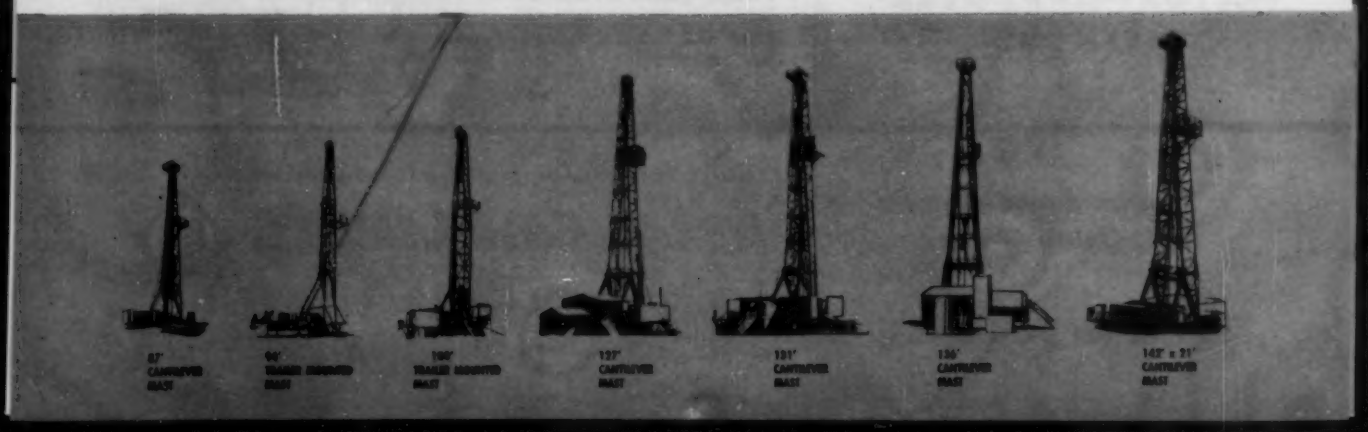

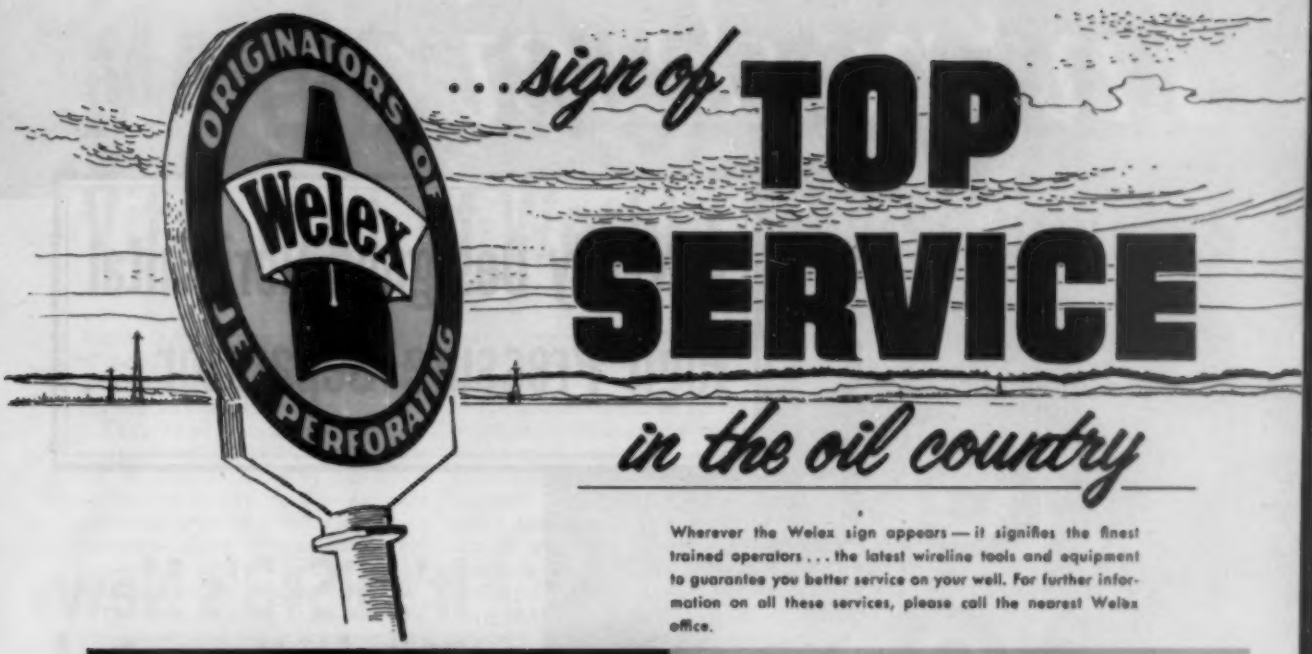

. . . sign of TOP SERVICE in the oil country

Wherever the Welex sign appears — it signifies the finest trained operators . . . the latest wireline tools and equipment to guarantee you better service on your well. For further information on all these services, please call the nearest Welex office.

1 ***Jet Casing Perforating***
A jet for every completion need.

2 ***Simultaneous Radioactivity Logging***
New magnetic collar locator for greater accuracy.

3 ***Open Hole Perforating***
Powerful Welex Torpedo Jets for maximum performance.

4 ***Down Hole Junk Shots***
For fast cleanup of fishing jobs.

5 ***Thru-Tubing Perforating***
Welex "Swing" Jets for the best permanent-type completions.

6 ***Formation Fracturing Tool***
Shattering power for pre-fracturing jobs.

7 ***Wireline Squeeze Cementing***
"Spot" Cementing—just where you want it.

8 ***Other Associated Wireline Services***

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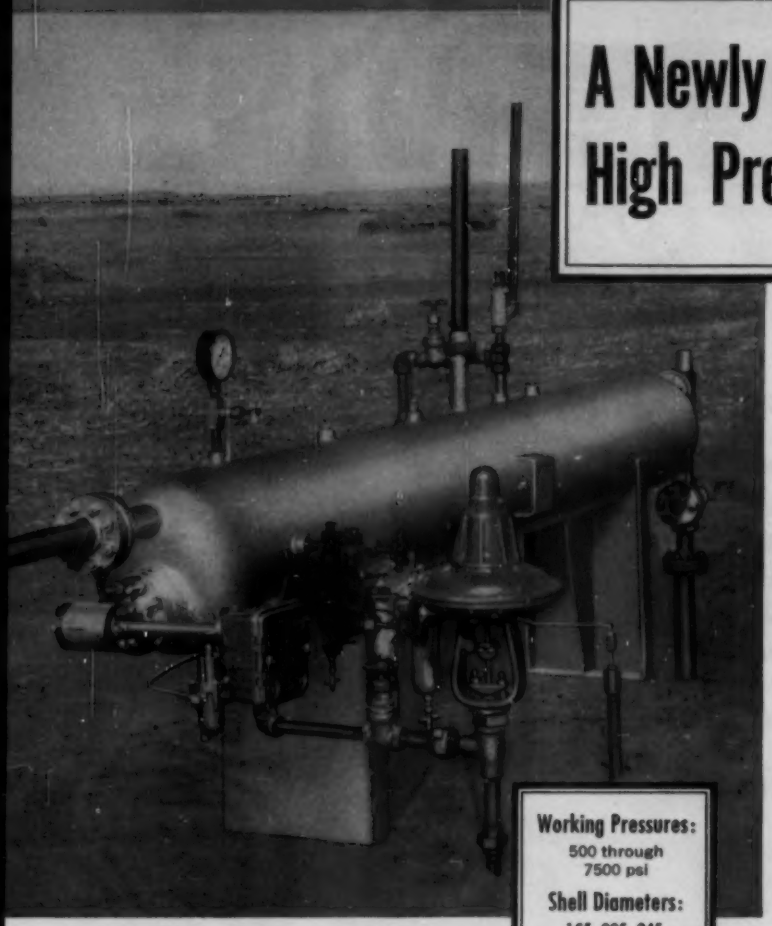
Introducing...

A Newly Designed Horizontal High Pressure Separator...



Working Pressures:
500 through 7500 psi

Shell Diameters:
16", 20", 24", 30", 36", 42".

It's BS&B's New Single Barreled Model DC!

The exclusive internal design of the new BS&B Model DC Separator has been developed as the result of extensive laboratory and field testing, and is considered to be a substantial improvement over that of any other horizontal separator available today.

Within its single horizontal cylinder the Model DC provides a large gas-liquid separation chamber, a large liquid collecting and surge chamber, and a highly efficient mist extraction section.

FEATURES

1. Separation Efficiency. Model DC utilizes a highly efficient inlet deflector as a primary separating element and combines a turbulent-free separation section with an efficient mist extractor section to remove liquid particles 10 microns in size and larger.

2. High Capacity. Dual gas and liquid chambers in a single barrel provide a large surge capacity.

3. Maximum Release of Solution Gas. Maximum liquid retention and large liquid surface area permit maximum release of solution gas.

4. Cold Weather Operation. The internal design of the Model DC gives excellent cold weather operating characteristics.

5. Sensitive Controls. Model DC utilizes the excellent BS&B Type 889 Liquid Level Controller with the BS&B Type 1450 Pilot, which has throttling and snap action range and gravity adjustments. The displacement element is located in the turbulent-free liquid chamber to effect constant interface level.

6. Convenient Hook-Up. All of the controls are located at one end and on the same side of the separator for convenience and neat appearance.

For detailed information on the BS&B Model DC Separator, contact your BS&B Representative, or write to...

OVER 60 YEARS
BS&B
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

Oil & Gas Equipment Division, Dept. 1-C3
1708 West Main Street Oklahoma City, Oklahoma

MARVEL INVERSE OILER—

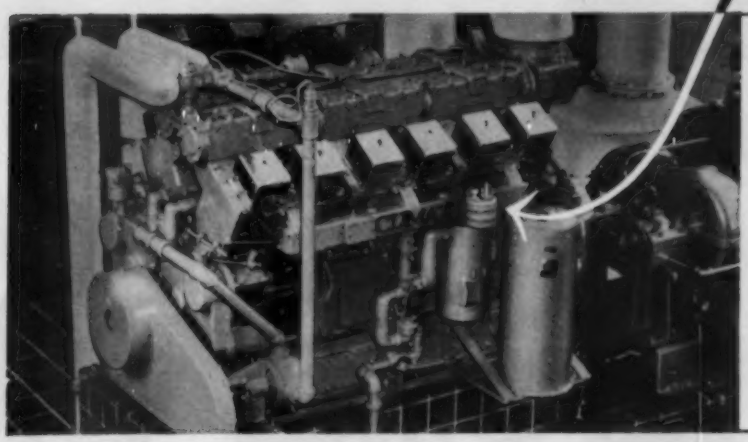
Vital Part of World's Finest Engines

Engine manufacturers think so highly of the Marvel Inverse Oiler they have incorporated it as a vital unit in their engines' lubrication systems.

They have found that engines, equipped with Marvel Inverse Oilers, can be depended upon to give quick acceleration to save trip time . . . keep operating costs to a minimum . . . guarantee hours of continuous performance . . . keep "down-time" low by extending periods between overhauls.

The famous Climax Engines, one of which is pictured below, is an example. A truly fine performer, it is equipped with a Marvel Inverse Oiler for Marvel Mystery Oil—finest performing lubricant of all.

The Marvel Inverse Oiler feeds Marvel Mystery Oil in exact proportion to engine speed and load . . . properly lubricating valves and guides, preventing wear and sticking. Keeps upper piston rings free in their grooves . . . retards ring flutter . . . and cushions ring pounding which can result in ring breakages. Remember, it is the *oil* which must do these things and only Marvel Mystery Oil is blended for this purpose and for this oiler.



The Marvel Inverse Oiler

is an integral part of the Climax 12 cylinder, 171 H.P., 600 RPM GAS ENGINE. Operating off the intake manifold, this completely automatic Oiler feeds Marvel Mystery Oil exactly in proportion to engine loads . . . gives direct protection to the all-important upper cylinder areas.

This Chart shows the proper setting for constant load engines

BRAKE H. P. AT BELT	NAT. GAS CU. FT. PER HOUR	BUTANE GALLONS PER HOUR	GASOLINE GALLONS PER HOUR	M. M. OIL DROPS PER MIN.	M. M. OIL HOURS PER QUART
10	115.	1.07	1.12	4	228
15	172.5	1.60	1.68	6	152
20	230.	2.14	2.24	8	114
25	287.5	2.67	2.80	10	91
30	345.	3.21	3.36	12	76
35	402.5	3.74	3.92	14	65
40	460.	4.28	4.48	16	57
45	517.5	4.81	5.04	18	50
50	575.	5.35	5.60	20	45
60	690.	6.42	6.72	24	38
70	805.	7.49	7.84	28	32
80	920.	8.56	8.96	32	28
90	1035.	9.63	10.08	36	25
100	1150.	10.70	11.20	40	22
120	1380.	12.84	13.44	48	19
140	1610.	14.98	15.68	56	17
160	1840.	17.12	17.92	64	14
180	2070.	19.26	20.16	72	12
200	2300.	21.40	22.40	80	11
225	2587.5	24.00	25.20	90	10
250	2875.	26.75	28.00	100	9
275	3162.5	29.42	31.10	110	8
300	3450.	32.10	33.60	120	7

Chart shows total oil consumption

EXAMPLE:—If you use 805 cu. ft. of dry gas, 7.49 gallons of butane or 7.84 gallons of gasoline, your H.P. is about 70, so adjust oiler to feed 28 drops per minute. You will then receive about 32 hours per quart of MARVEL MYSTERY OIL.

If engine load increases after setting for normal load, oiler will automatically increase its feed, decreasing when load is lessened.

To determine drop count per oiler when more than one is used on an engine—divide recommended drop count by number of oilers.

NOTE: Guarantee on oiler is void if any other oil than MARVEL MYSTERY OIL is used. Some *engines* also carry this guarantee policy.

See Your Local Jobber or Oil Well Supply House

EMEROL MFG. CO.

Dept. 427, 242 West 69th Street New York 23, N. Y.

PREVENT TROUBLE BEFORE IT STARTS

SPECIFY O·C·T

ALL THE WAY

O-C-T FLOW CONTROLS save up to 90 per cent in cost and 70 per cent in weight when used to replace conventional wings. Gate valve and seat may be replaced by one man in five minutes.

O-C-T CHOKES are available in three positive types and three adjustable types for all pressure ratings and production situations.

O-C-T FLANGES AND FITTINGS are made in a complete range of sizes, styles and pressure ratings to meet any Christmas Tree requirement. Only the finest materials and heat treatments are used.

O-C-T TUBING HANGERS are available in styles to meet any completion requirement. Special attachments are available to permit drilling-in, running and landing tubing under pressure.

O-C-T TUBING HEADS are made in four basic types for every pressure and completion requirement—from extreme pressure 30,000 lb. test, down to special low-cost heads for pumping wells.

DOWN

The best way to prevent disastrous equipment failures and unnecessary workovers is to specify high quality equipment of the right design in the first place. O-C-T offers the finest equipment available and has the largest service organization in the field to help set and service well-head assemblies. Whatever your completion problem, O-C-T has a safe answer that will save you money by preventing trouble before it starts.

O-C-T CASING HANGERS are offered in six different types to meet every price limit and completion practice. The C-19 is the fastest and safest casing hanger available today.

O-C-T CASING HEADS are available in four basic types to satisfy any requirement of price, pressure rating and completion program.

O-C-T PRODUCTION PACKERS run in easily, set easily, seal positively under severe conditions and release without difficulty. They are available in two types, either with or without packer hold-down.

O·C·T

OIL CENTER TOOL CO.

P. O. BOX 3091, HOUSTON, TEXAS

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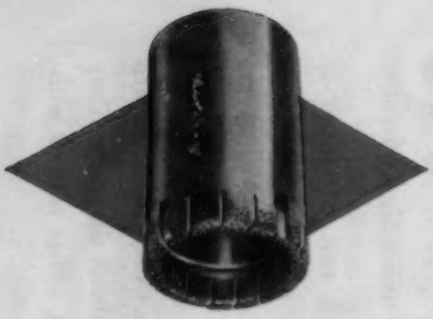
D & S washover shoes save time... money!



Drilling & Service Truco diamond washover shoes have performed many extraordinary feats in the oilfield. We cite one example here which tells a graphic story of advantages in using D&S washover shoes for *your* operation:

Recently, one customer had 7" casing set through pay zone. The casing was perforated and a packer set with 2½" tubing. When he started to sandfrac the well, the casing collapsed around the tubing. After backing off the tubing... leaving one joint up for a guide, a 5-15/16" x 4-5/8" D&S diamond washover shoe was run on 5½" OD wash pipe... cutting over the tubing, packer and cutting out the collapsed casing. This was done in *three days' rig time!* When the wash pipe was pulled, the tubing, portion collapsed casing, packer and anchor joint were retrieved inside it.

Total Truco diamond washover shoe cost was only $850. Experience in this type of operation has shown that conventional methods would have required *more* rig time and *higher* related costs.

WRITE OR CALL TODAY! One of our sales engineers will call on you and explain our custom-services and equipment. Herein lie the real D&S advantages.

DIAMOND CORING BITS
Fast penetration, full core recovery.

DIAMOND DRILLING BITS
More footage, less rig time.

DIAMOND WASHOVER SHOES
Fast "Fish" recovery.

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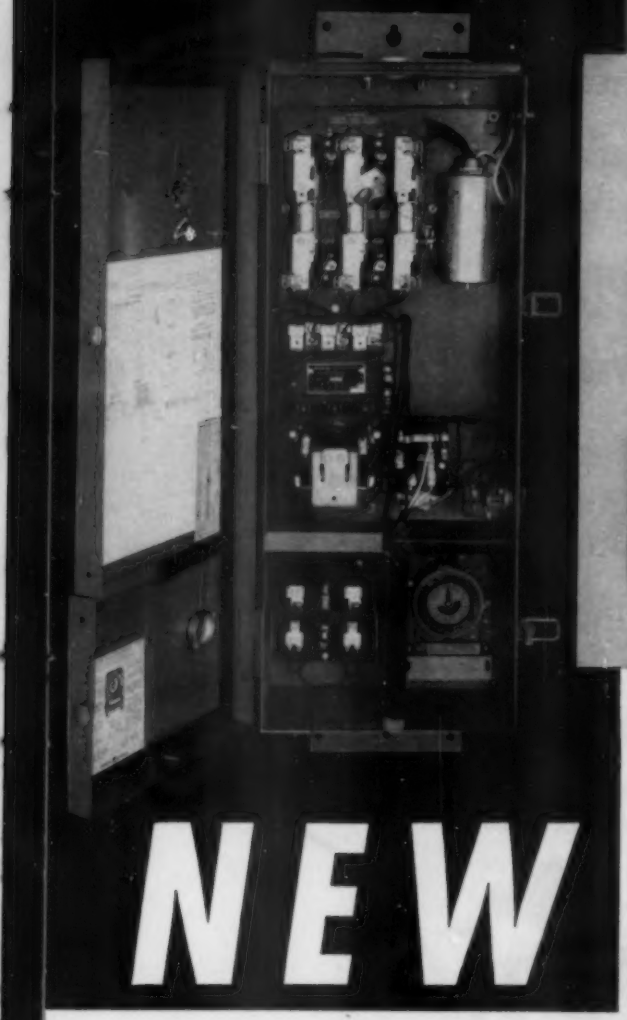

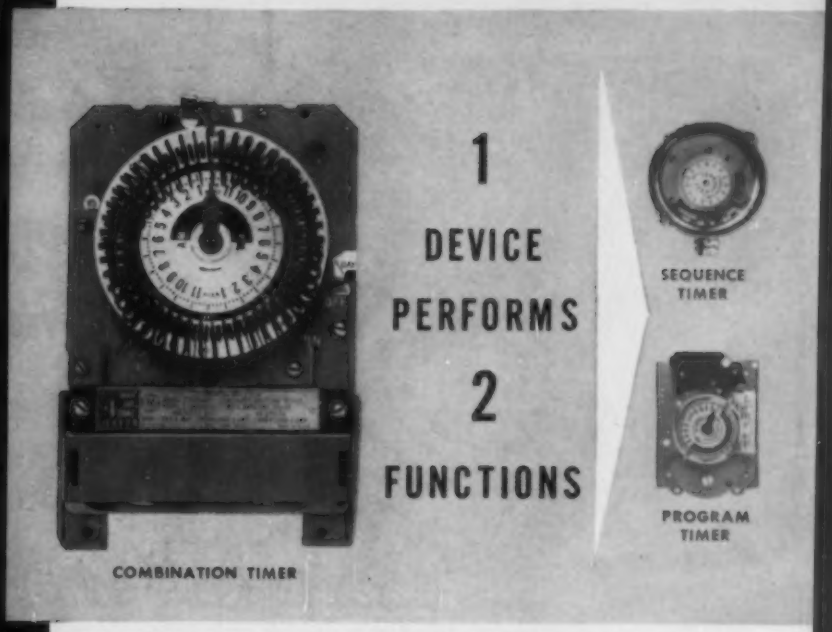

NEW COMBINATION TIMER performs functions of program timing, and automatic sequence restart. It is now part of every G-E oil-well pumping starter.

NEW

Timer Now Standard on All G-E Oil-Well Pumping Starters

G-E oil-well pumping starters are now equipped with the new G-E combination timer. Because this device combines in one unit the functions of program timing, and automatic sequence restart, it has gained wide acceptance in the oil fields. This new timer design means big savings in time and easier operation.

Program timing is especially easy. Toggle tabs which flip toward the center of the dial make control of ON-OFF operation a simple matter, even with a gloved hand. Tabs are spaced at half-hour intervals to make tab settings easy. If desired, the toggle tabs can be moved for 15-minute pumping periods.

Automatic sequence restart provided by the timer helps prevent overloading of the power supply when several motors restart at the same time after power failure. No settings or adjustments are necessary. Momentary contacts, which are closed for only a few seconds out of every four minutes, control sequence restart. After a power failure, the pumping motor will start only when these contacts are closed and the program tabs call for pumping.

Other outstanding features make the G-E oil-well pumping starter the best you can buy. Some of these features are:

- High drop-out undervoltage relay better protects motor windings. If line voltage drops to approximately 70 percent, the undervoltage relay opens the line contactor, and helps prevent overheating the motor.
- Undervoltage relay circuit provides better "single phasing" protection. Loss of power on any line prevents the controller from energizing the motor under single-phase conditions.
- Gasketed starter enclosure is designed to keep out dust, snow, sleet and rain.
- Separate ventilated overload relay compartment reduces the possibility of unnecessary tripping due to excess heat from the sun.
- 15-minute definite-sequence restart timer is available for use where a demand charge is made by the utility company.

GENERAL ELECTRIC

SEE THIS NEW OIL-WELL PUMPING STARTER AT YOUR NEAREST G-E APPARATUS SALES OFFICE OR DISTRIBUTOR—OR SEND IN COUPON BELOW.

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Please send me a copy of your new bulletin GEA-6410, covering control for oil-well pumping. I want this for:

☐ reference only ☐ immediate project

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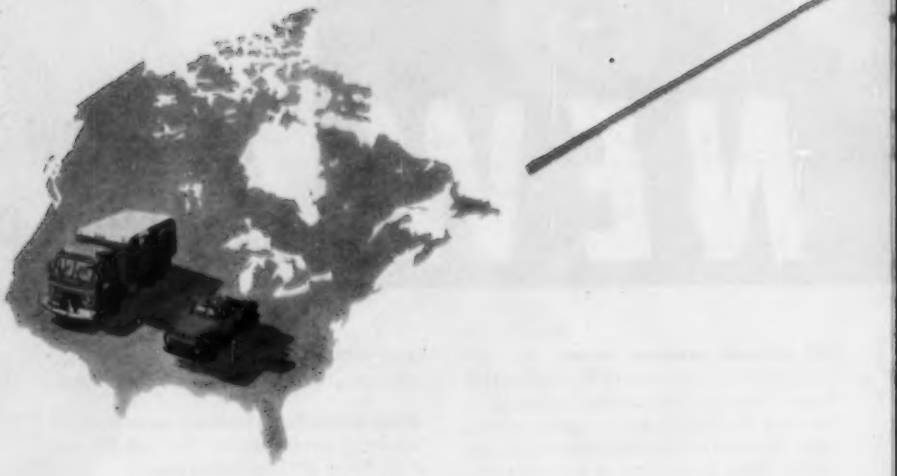

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Now, to continue furnishing the oil industry with the best, we have joined forces. Our accumulated experience, research and engineering facilities are combined to let us keep on leading through strength. From this new association comes the strongest possible service organization—an organization devoted to the more precise measurement and evaluation of your formations.

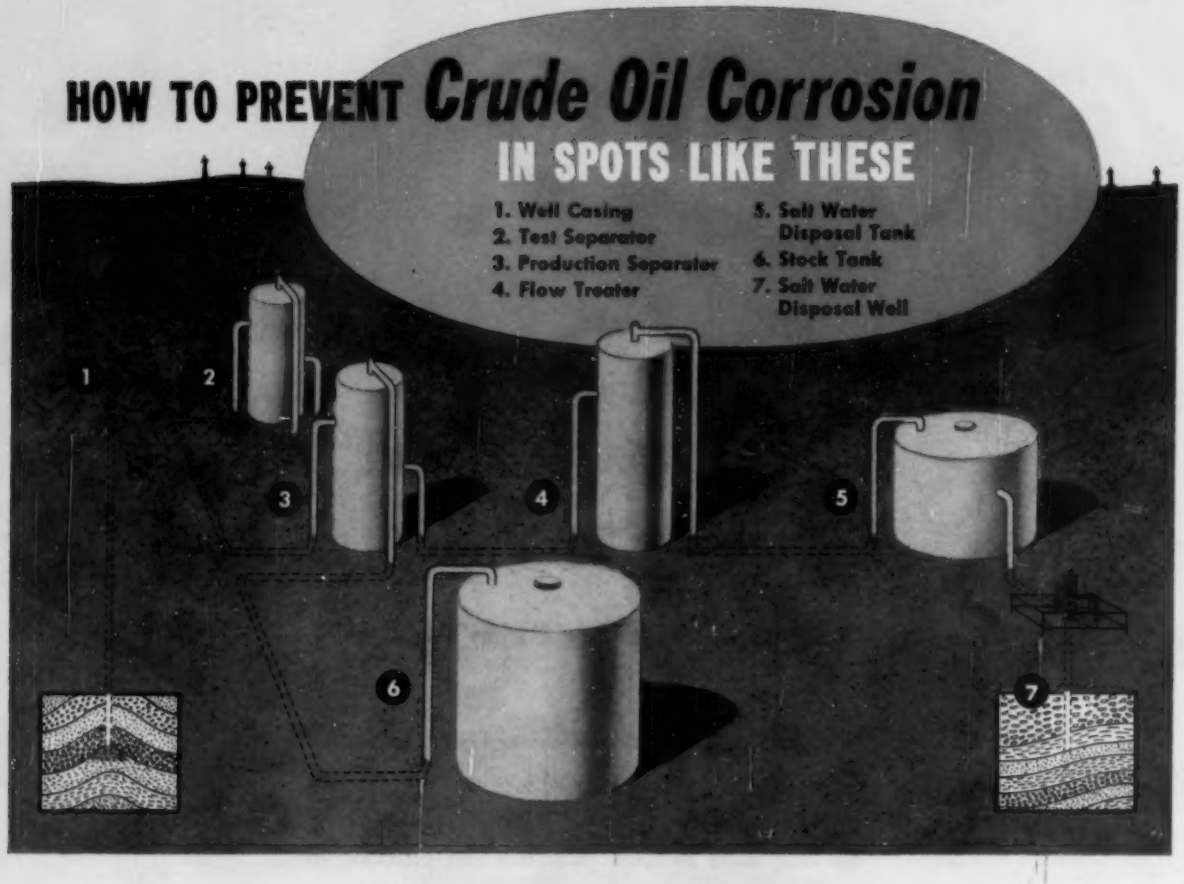
J. Schlumberger

President

SCHLUMBERGER WELL SURVEYING CORPORATION

HOW TO PREVENT *Crude Oil Corrosion*

IN SPOTS LIKE THESE



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HERE'S an important new weapon for controlling costly crude oil corrosion. It's TARSET—the effective new *coal tar-epoxy resin* coating. In test after test, Tarset has proved that it can stop corrosion caused by sour crude in storage tanks and in a growing number of other pieces of crude oil handling equipment.

Tarset is the toughest, hardest coating of its kind ever produced from coal tar. It will not shatter at −30°F. or soften at 400°F. It is superior to all other coal tar coatings in its ability to adhere to metal and concrete. And Tarset is easy to apply by brush, roller or spray.

If you have a corrosion problem—above ground or below—call on *Pittsburgh*. Without obligation, our engineers will gladly tackle your specific crude oil corrosion problem . . . and come up with dollar-saving answers. Let us hear from you today.

Send for Descriptive Booklet on TARSET today

Free booklet tells how to use amazing new Tarset to reduce costly corrosion. Gives detailed description of Tarset's specifications, properties and application characteristics. Write for *your* copy today!

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1½" SLIDE VALVE MANDRELS

For Dual Strings Inside 5½" O.D. Casing

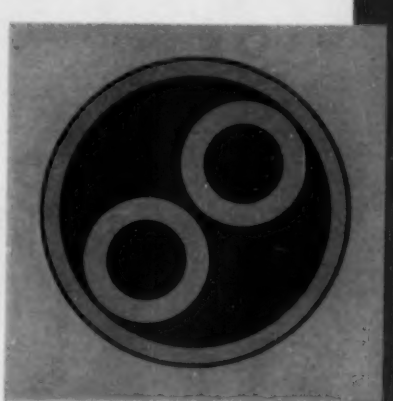
Here's the way to faster, safer, more economical dual completions! These new GOT mandrels permit dual strings equipped for gas lift and circulation to be run **without clamping** inside casing as small as 5½" O.D. 20#. Ample clearance is provided for separate running and pulling; shoulders are bevelled for easy passage.

All types of GOT pressure charged wire line retrievable gas lift valves are furnished for the Type "SSC" 1½" Mandrels. Without the valves, these mandrels serve as full capacity circulating valves.

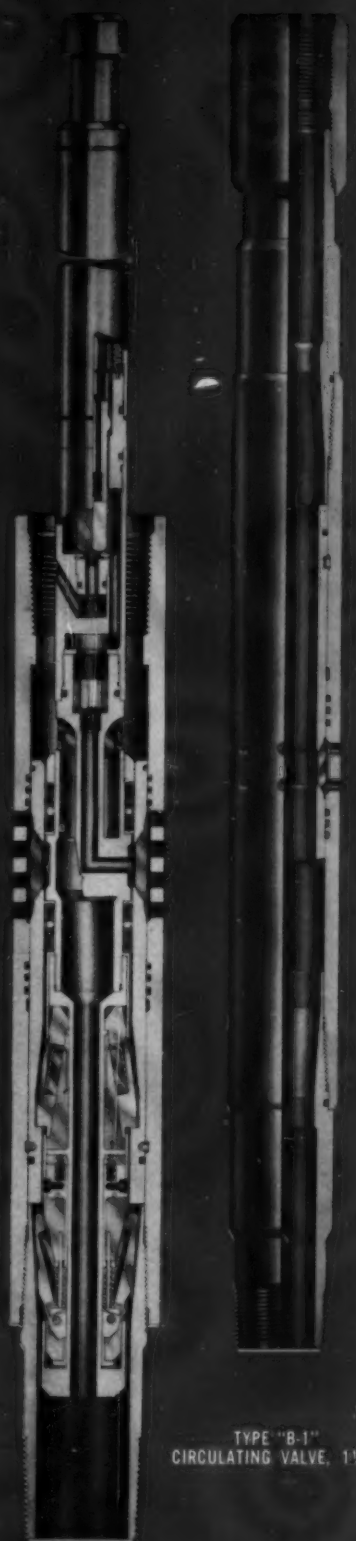
Type "B-1" Circulating Valves are full 1½" capacity. Both tools are full opening and permit use of standard 1½" tubing tools and instruments. Sliding sleeves are stainless steel, with positive O-Ring pressure seal.

Save time and money in your dual completions. Plan them around GOT 1½" sleeve valve equipment. Only the size is new . . . the principle has been proved in hundreds of dual completions using 2" equipment.

This illustration shows the relative clearance of GOT 1½" sleeve valve equipment inside 5½" O.D. 17# casing.



ASK YOUR GOT REPRESENTATIVE FOR FULL INFORMATION, OR WRITE FOR CATALOG NO. 56-GL.



TYPE "B-1" CIRCULATING VALVE, 1½"

TYPE "SSC" VALVE AND MANDREL, 1½"

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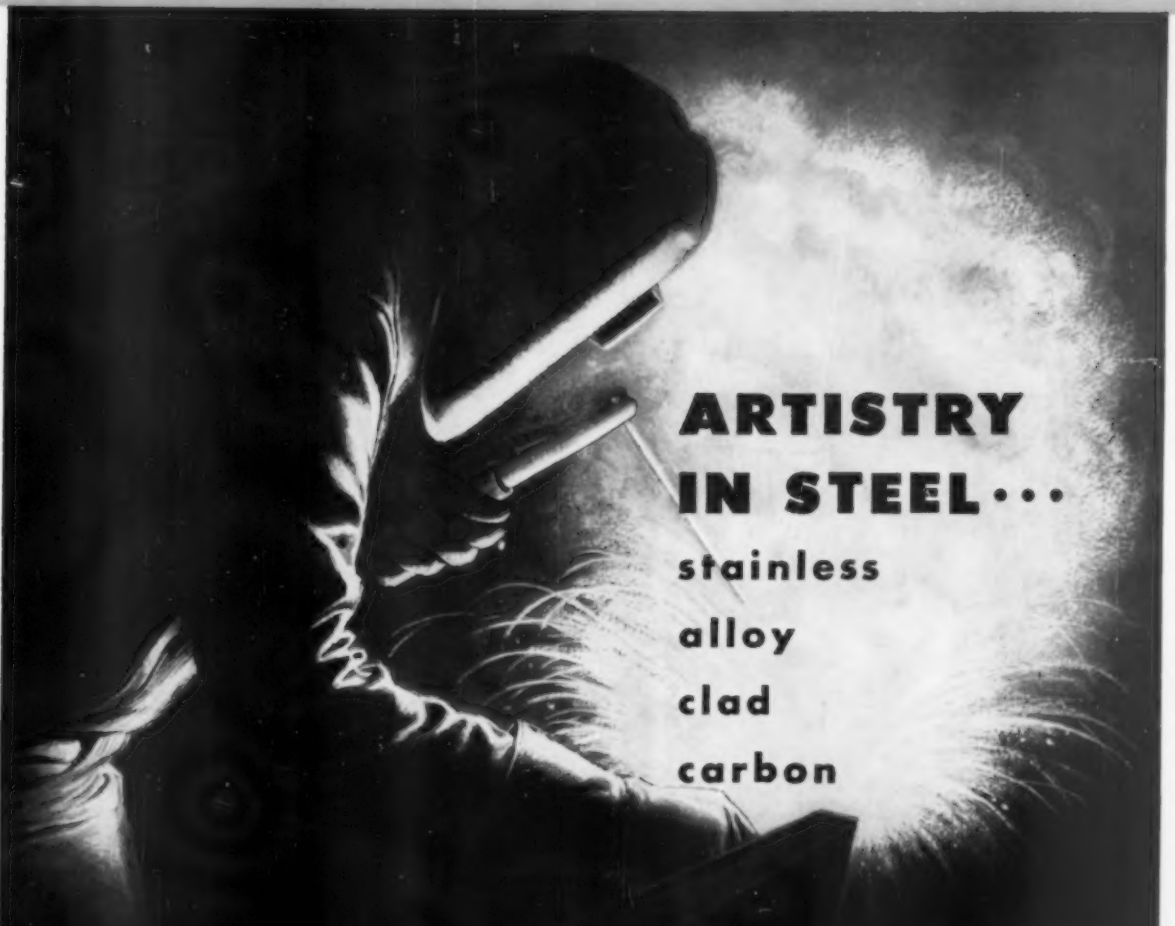

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Skill with the torch, or any of a hundred different tools of the trade—in steel fabrications, massive or small—is fairly obvious in the quality of the finished product. The extra touch of Sun Ship's professional skill—acquired through years of countless difficult jobs—adds artistry ...which is evident in product performances and dependability beyond the demands of industry.

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for lean oil feed at AMBROSE GASOLINE PLANT...

Photo by E. M. Payne

Ingersoll-Rand HMTA Pumps were chosen by Cities Service Oil Company. Three turbine-driven 5-stage pumps, with the I-R Unit-Type rotor assembly, serve the two absorption towers at this Blackwell, Oklahoma plant, designed and built by Hudson Engineering Corp. Present conditions call for 1650 gpm of 0.795 sp. gr. lean oil at 610 psig, but the ultimate designed production rate will require a lean oil pressure of 810 psig. The additional head will be developed by operating the pumps at increased speed. Perfect radial balance at both conditions of operation is assured by the multiple-volute fluid passage design of these HMTA pumps.

Other Ingersoll-Rand pumps at this new plant are on tower reflux, loading, still reflux, boiler feed and water circulation services. Three Ingersoll-Rand 8-cylinder gas engines supply the plant's electric power.

Your liquid moving requirements can be best met from the complete Ingersoll-Rand process pump line. Your nearest I-R office will be glad to study your needs and recommend the right pumps for your job.

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NEWS and COMMENT

Scientists – Fuel Pumps – Atom Smashers – Automation

SHALE OIL RESERVES GROW RAPIDLY, to judge by old estimates as compared to the most recent figures. Bureau of Mines, always a conservative estimator, has said earlier that we have in Colorado alone some 493 billion barrel of shale oil in situ. Now comes the U. S. Geological Survey before the National Western Mining Conference, deposes and says Colorado has nearly twice that much shale oil reserves in deposits that will yield 15 gal or more per ton of raw shale. When to this knowledge is added the facts that good and efficient mining, crushing, retorting and refining methods have been developed, the stentorian yowl of the political demagogue that we are rapidly running out of hydrocarbon fuels, etc., takes its place along with many other political absurdities, believable only by the totally uninformed. Private companies are taking up the task of going further in research to improve all these methods for future needs.

★ ★ ★

AND A BIGGER "DEMONSTRATION" plant for shale oil will be built by Union Oil Company of California, long in the forefront of shale research and development, "father" of an outstanding process and unit for shale retorting, which is located at Rifle, site of the extensive Bureau of Mines research projects. Built by Stearns-Rogers Manufacturing Company at Grand Valley, Colorado, it will handle a larger but unannounced amount of shale than the 30-ton-per-day pilot unit now in operation. Also, Denver Research Institute with the backing of Oil Shale Corporation, is planning a pilot plant that, it is hoped, will reduce the cost (of motor fuel presumably), from the current estimate of 16¢ per gallon to 13¢, thus coming more nearly into line with costs for petroleum gasoline.

★ ★ ★

BILLIONS FOR CHEMICAL PLANTS during the next three years, says MCA (Manufacturing Chemists Association to you), which estimates that in this period $2.3 billion will be spent by that industry for plants and expansions alone. In 1955, $722,000,000 was spent, and $1.6 billion will be sunk during '56 and '57. Forty-three states are sharing in this expansion. Who's the biggest? You guessed it—arrogant Texas, with $415,000,000 set aside for the period, with 66 projects; California is second with 49 projects.

MANY AMERICAN FIRMS have experimented with propylene polymerizing reactions. Standard of New Jersey, and of Indiana, Phillips, using a low-pressure, chromic oxide process, claims molecular weights up to 50,000. Experts believe polypropylene may someday match polyethylene in amounts produced.

★ ★ ★

POLYPROPYLENE IS THE CINDERELLA, the "neglected orphan" of the high polymer field, while Big Sister Polyethylene gets all the attention and all the money spent on her. But European companies are giving PP-ene a tumble; Montecatini, (Italy) has been her sole Beau for some time; J. Natta of Milan Polytechnic Institute is the developer of this process that appears to be similar to Ziegler's low-pressure process, Germany. Patent situation nebulous, now. In Britain, Petrochemicals, Inc., Shell offspring, is working on this three-carbon polymer. Hoechst & Huels are giving the matter the "works;" Germany's Hibernia licensed Ziegler long ago, is making polypropylene pilot plant-wise in a one-ton capacity unit. The Natta catalyst is a mixed metal halide-metal alkyl complex; lithium chloride is an example of a metal halide; tetraethyl lead is a common instance of a metal alkyl.

★ ★ ★

HIGHER COMPRESSION RATIOS aggravate the problems of deposits in the engine that promote surface ignition — preignition or detonation — and all new engines are raising the severity of these conditions. So, it is imperative that more intensive efforts be made to counteract these increased troubles, if tomorrow's engines are to function with proper satisfaction and efficiency, performance commensurate with their possibilities. And it is not too far-fetched to imagine that chemical addition agents, petroleum or non-petroleum derived, will give inevitably much of the solution of these rapidly mushrooming problems.

★ ★ ★

ADIPIC ACID FOR HIGH POLYMER production is in the offing for Monsanto-Lion combine. Multimillion-dollar unit started building at Barton plant, Luling, Louisiana, to use as charge stock "waste" products from that plant. New plant is to be operating by early next year. Part, at least, of product will go into polyurethane synthesis, 'tis said.

AMMONIA AND THE FARMER are each solving much of the other's problems. Beginning this year, the U. S. has more than 4,000,000 tons ammonia capacity. This will grow to nearly 5,000,000 (4,800,000) tons come early 1957, or tripled capacity in the last five years. While industry's increase in ammonia consumption is slacking off somewhat, the agriculture industry is consuming more and more, and this phenomenal rise in farm use as fertilizer appears to justify the new capacity that will be in operation by year's end. The number of units has grown almost as much — 19 in 1951, 52 in 1957. The huge proportion of this ammonia is petroleum-natural gas derived.

★ ★ ★

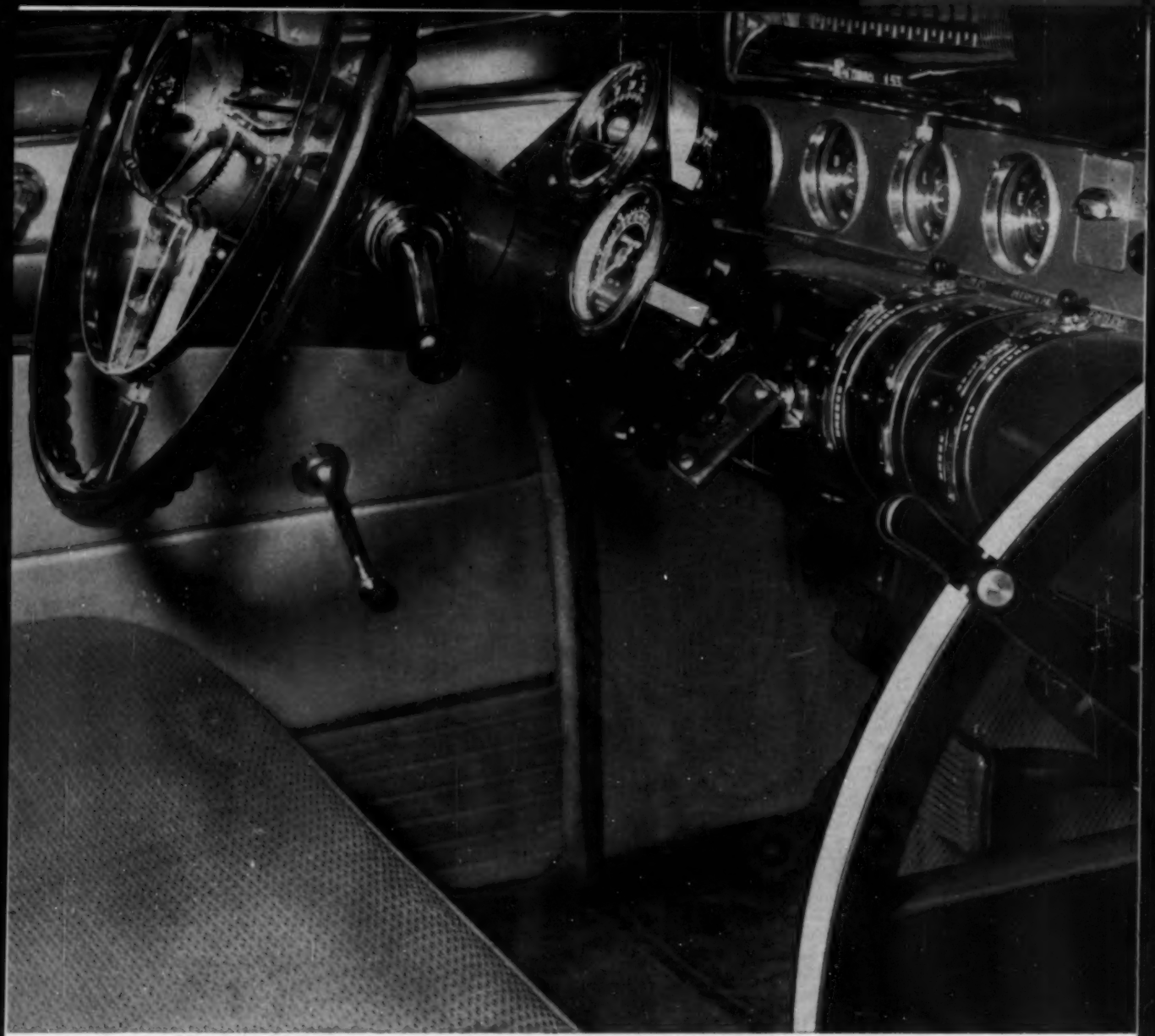
EIGHT BILLION DOLLARS is projected as the investment in the petrochemical industry by 1960, say chemical leaders. At present, with the investment of four billion, the industry has been doubling each five years. The natural gas-petroleum stock bin yields 3000 chemical substances and in 1956 will total 35 billion pounds of all products or ¼ the national tonnage.

★ ★ ★

AROMATICS FROM "LIGHT OILS." A new process, developed by a German development concern and sold by it recently to Koppers Company, Pittsburgh, Pennsylvania, is said to produce very highly refined aromatics, benzene, toluene, xylenes. Data on the process has not been disclosed.

★ ★ ★

BETTER ENGINES make bigger problems, according to recent statements of leaders in the fuels and lubricants ranks. Higher speed, higher compression pressures accentuate the severity of the conditions under which both fuels and lubricants operate. Deposits of different but always deleterious sorts follow as result of these strenuous conditions. Lubricating oil "life expectancy" may well be increased greatly, says Canadian National Research Council, by sticking a piece of a special sodium metal alloy into the oil line (presumably between oil pump and oil distributor head) of an automotive engine and leaving it there. It is said to retard formation of oxidation products in the oil. Car engines systems so provided have operated two years, 17,000 and 20,000 miles, without an oil change. The experiment is being tried out in a large number of units.



Above, test car with minimum instrumentation needed for fuel rating.

How Ethyl Research equips a car for accurate fuel ratings

Ethyl Research has for years been active in developing more accurate and economical ways of obtaining fuel ratings on the road—offering refiners convenient methods for evaluating their gasoline stocks.

At Ethyl Laboratories, we have found that the various road rating procedures can be adequately handled by a grouping of just five instruments, some of which can be seen in the picture above. But we have discovered that the addition of other key equipment (see right-hand page) can facilitate your road testing operations.

Our people have accumulated hundreds of thousands of miles of road testing experience with this equipment. If you would like more

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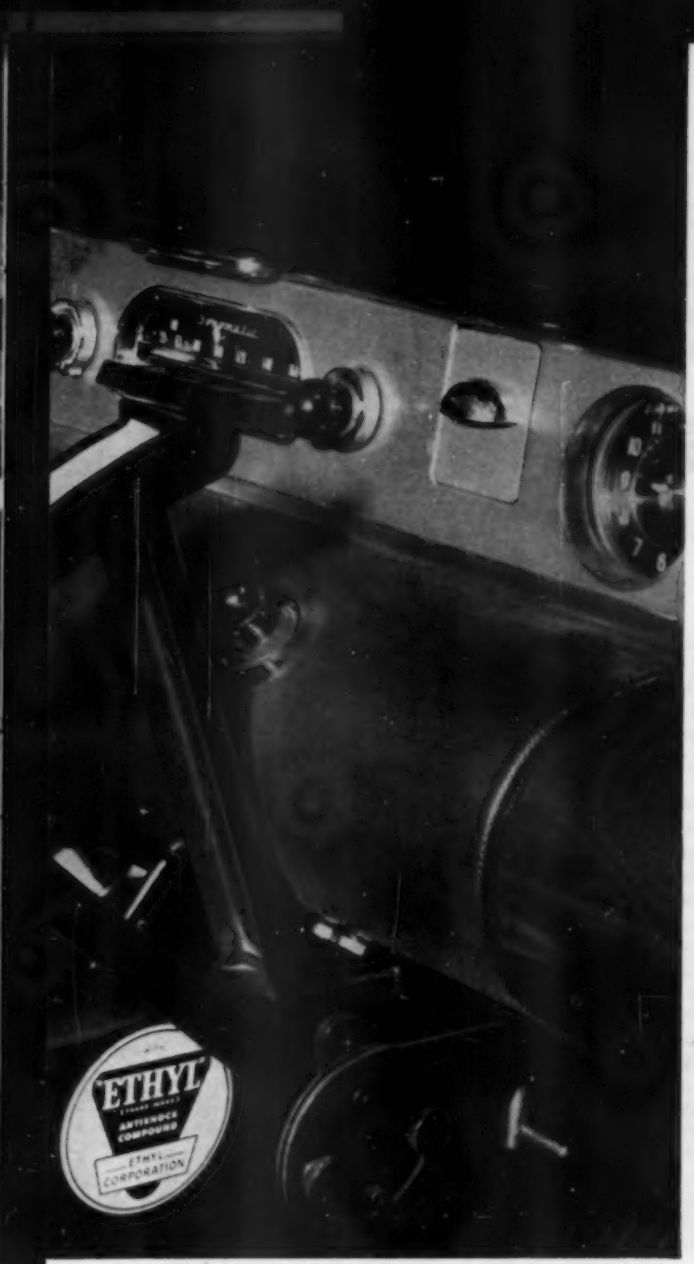

Right, equipment suggested for more complete test-car setup.

information about this subject, please contact your Ethyl technical representative.

INSTRUMENTS SHOWN in this advertisement have proved satisfactory in Ethyl test cars but are not necessarily endorsed by Ethyl Corporation. Although the products of some specific manufacturers are shown, several of the instruments are made by various companies, and we'd be glad to mail you a list of sources. Just send your request to Box 12, Ethyl Corporation, 100 Park Avenue, New York, N.Y.

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Electronic spark protractor provides an accurate method for continuous indication of spark advance. It gives direct readings at all speeds.

Timing light (above), calibrated flywheel and sight tube are used for obtaining instantaneous spark advance position. Flywheel is marked in crankshaft degrees.

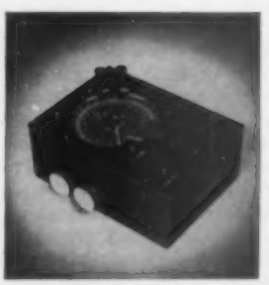
Auxiliary fuel system facilitates testing of several fuels in succession. Simple coupling connects the auxiliary line to the inlet side of the fuel pump.

Tachometers are accurate mechanisms for measuring the engine speed. They are adaptable for operation with any six- or twelve-volt system.

Vacuum gauge is required for part-throttle ratings. At any given car speed, the vacuum gauge permits reproducing part-load conditions.

Selector switches for thermocouples and resistance bulb thermometers are needed to permit reading temperatures at various locations.

Thermocouples and resistance bulbs are used to measure the temperatures of the coolant, the lubricating oil, and the air entering the carburetor.



Potentiometer is used to indicate the temperatures measured by the thermocouples. Road ratings require a rugged instrument, insensitive to vibration.

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EXCLUSIVE

Residual Fuel Oil

Heavy fuels, lowest priced of all petroleum products, losing ground to distillates; some new uses delaying trend

Where Is It Going?

Arch L. Foster
Editor, Refining & Petrochemical Edition

STRANGE as it may seem, indications now are that, while consumption of heavy residuals as primary fuels is on the downgrade, these heavy, low-priced fuels are not on their way out. At least, not in the near future. As will be indicated here, the market advantage for heavy fuels is purely economic; if the price goes high enough for the refiner to balance his budget in the light of crude prices, then it will become too expensive for use in many applications. Consequently, in the long run, the fate of residual fuels rests on price to consumer, which in turn will be dictated by the value of the material as source of material for other uses — asphalt and road oils; cat cracker charge; gas turbine and diesel fuel; hydrogen and "synthesis gas" as petrochemical intermediates; and sundry other possibilities.

Residual fuels have come a long way since being disposed of in burial pits, then burning pits; burned under "cheesebox"; then under shell stills and eventually pipe stills. The Great Emancipation came when residue fuels went to work in locomotive fireboxes, teaming with thermal cracking, back in the 1920's, which then new process produced more heavy fuel and more patent litigation than any process before or since.

Price levels then were such that the railroad use was worth it. The terrific strides made in that period in application of the gasoline engine to public and private transportation made gasoline such a premium product that the residue could be sold at practically any price and the refiner still made money. The motor fuel from cracking, with its boost to anti-knock properties was the "cayuse" that carried the "Mexican Saddle" of fuel oil losses.

Several factors have combined to puncture the balloon of residual fuel consumption (production, too). Back in the Bad Days of the 1930's, General Motors, via the instrument of its Electro-Motive Corporation, began the development that culminated in the introduction of the diesel-electric locomotive. Starting out gingerly with a few units running the "long-legged miles" of the Santa Fe Los Angeles-Chicago main line, numerous problems, attendant with the carrying out of any new system or operation, were met and handled, and the death knell of the fuel oil-steam locomotive was sounded by every "tin whistle" that blasted across the prairies from the big diesels.

For the diesel-electric offered many advantages over the older, romantic steamer. Its draw-bar pull is heavier, continuous; only reciprocating motion is that of the huge diesel pistons, ironed out into one continuous push in the electric motors' rotation. The diesel-electric will do as much work on $1 worth of distillate (diesel) fuel as the old fuel oil-steamer would do on $2 worth, and do it more efficiently. Also, the diesel solved the problem of large quantities of suitably treated boiler water with its chemical treating units, "lake impoundment" units, right-of-way tankage, etc. More than 90 per cent of this demand is out the window, the diesel needing only engine-jacket cooling water in comparatively infinitesimal quantities. Eliminating this demand for water rubbed out $50,000,000 of this equipment.

So, in the last 10 years, 20,924 new engines have been ordered, only 468 of them (2.2 per cent) being steam locomotives.

Some 50 major lines have *no* steam locomotives at all! Eighty per cent of all passenger trains, and 86 per cent of all freights are drawn now by diesel-electrics. Now on order (November, 55) are 800 diesel-electrics, some individual orders calling for as many as 50 new units, priced at $10,000,000. Soon, apparently, the steamer will join the dodo bird — in a glass case.

Too soon to see the impact of gas turbine locomotives on railroad economy, but here the trend and effect is the other way. Gas turbines, reports say, can use heavy fuel oil profitably. If this is economic operation, it is possible that residual fuels may come into their own again, in tomorrow's gas turbines.

Furthermore, extensive experiments are being carried out on a large scale to see if heavy residues can be blended with distillate fuels, or even be used alone, in railroad and diesel ship engines to reduce the operating cost. Current reports say that this blended fuel is proving economical in diesel-electrics. It is doubtful if enough experience has been had to determine the comparative efficiency in maintaining engine operating schedules, short repair time and parts replacement costs when using heavy fuel in the blends. But so long as the price of residual fuels is well below that of distillate diesel fuels, the outlook is hopeful for residuals.

In motor ships, it is reported that one-third the fuel bill can be saved in operating a large ship's diesel, as compared to distillate fuel. Esso Standard has been operating one ship for a year on all-residual fuel. It burned 50,000 bbl of the heavy stuff, saved $69,500 net. Esso spent $30,600 in refitting the power plant for residual fuel. Since 1951, use of heavy fuel has risen from 2,000,000 bbl annually to nearly ten times as much. Since 60 per cent of the ships built in this period are motor (diesel) ships, the potential savings by adoption of residual fuels is enormous. This trend, of course, will have the effect of expanding residual use, tend to keep the heavy fuel in the running. Residual fuel now costs 60 to 65 per cent as much as distillate. And, as to locomotive fuels, recent word comes (January, 1956) that Union Pacific Railroad has ordered, or is very soon to

TABLE 1. Consumption of distillate and of residual fuel oils, 1941-54.

	Railroads	Heating and range oil	Industrial uses	Gas and electric power plants	Vessels	All other[2]	Total
Distillate Fuel Oil.[1]							
1941	13.5	342.4	28.3	14.1	29.9	45.2	473.5
1946	48.8	411.4	59.2	29.4	33.5	83.1	665.5
1947	64.8	521.0	67.2	39.0	39.7	85.6	815.2
1948	84.4	581.1	81.4	40.4	39.5	103.7	930.5
1949	105.8	555.4	72.4	34.4	36.0	98.2	902.1
1950	133.3	645.2	101.6	36.1	35.2	130.4	1081.9
1951	163.7	726.1	116.2	26.2	39.3	153.9	1225.4
1952	184.9	759.6	116.3	22.7	46.8	172.9	1303.2
1953	205.9	774.4	116.0	18.7	46.2	176.1	1337.2
1954	212.0	877.3	113.9	16.6	42.6	179.5	1442.1
Residual Fuel Oil.[1]							
1941	222.1	128.5	215.2	92.7	156.3	235.7	1050.5
1946	270.8	134.3	267.3	137.5	238.1	267.1	1315.1
1947	266.1	153.9	314.1	166.4	278.1	241.9	1420.6
1948	241.9	158.3	318.0	153.4	258.6	237.4	1367.6
1949	174.3	165.9	336.7	219.9	245.4	216.8	1359.0
1950	166.7	199.1	405.5	254.8	254.4	236.8	1517.2
1951	151.0	209.0	431.7	193.6	293.7	267.3	1546.3
1952	110.4	215.8	431.9	192.2	301.1	265.5	1516.8
1953	77.4	222.5	453.3	232.0	310.8	239.3	1535.5
1954	44.3	215.6	440.9	194.3	298.9	236.5	1430.4

[1]Distillate fuel oil sales reported by U. S. Bureau of Mines adjusted to domestic demand.
[2]Includes military, oil company use and miscellaneous uses.
Data may not total due to rounding.
Source: Bureau of Mines.

TABLE 2. Consumption of petroleum liquid fuels, 1930-54.

Year	Gasoline consumption	Gas oil and distillate fuel oil consumption	Residual fuel oil consumption
1930	394,800	—	—
1940	574,469	160,851	340,163
1946	716,111	242,892	480,029
1947	779,410	298,273	518,510
1948	845,706	340,576	500,543
1949	893,221	329,270	496,021
1950	994,290	394,885	583,793
1951	1,090,354	447,778	564,397
1952	1,154,254	476,986	555,165
1953	—	488,475	560,474
1954	—	527,369	522,029

order, 45 gas turbine locomotives from General Electric Company that will use Bunker C (heavy residual) fuel oil. These locomotives will be turbine-electric, functioning as do diesel-electrics, with certain advantages. Most of those advantages, or *that* advantage, is that *no* reciprocating parts are used in the gas turbine; every main motion is rotational. The UP units are 8500 hp, designated and bought on the strength of the test results from 4500-hp units, also GE.

The story of residual fuel oil consumption is shown in Table 1.

Sales (Consumption) of Fuel Oils

In 1940, railroads used nearly 65,000,000 bbl of residuals, almost entirely in steam locomotives. Only 3,000,000 bbl of distillate fuels were used. By 1946, first full year after World War II, distillate fuels had grown to nearly 17,600,000 bbl, an increase of 585 per cent. In this time residuals consumption amounted to 100,000,000 bbl, or a growth of only 54 per cent. In 1952, residual consumption had grown to, really shrunk to, about 40,000,000 bbl, a drop of 39 per cent from 1940. Meanwhile, distillate fuel oil had climbed from 17,500,000 bbl in 1946 to 68,000,000 bbl in 1952, a rise of 290 per cent.

Distillate fuels, meanwhile, show an amazing growth curve in consumption. Heating oils dropped during the war years, percentagewise, but, starting in 1944 at 112,000,000 bbl, the figure climbs to 200,000,000 bbl in 1948, 263,000,000 plus in 1952. Similarly, ships used 61,500,000 bbl in 1940 of residuals, 13,000,000 distillate fuels. By 1946, ships were using 12,000,000 bbl of residual fuels, 88,000,000 of residuals. Up to 1952, distillates consumption in ships had grown to only 17,213,000 bbl (30 per cent) over 1940, while residuals rose from 61,225,000 to 110,500,000, or an increase of 49,000,000 bbl, or 80 per cent increase.

Total consumption amounts of distillate and residual fuel oils during this general period are even more significant (Table 2). In 1940, the country used up 161,000,000 bbl of gas oil and distillate fuel oil, and during the same time, 340,000,000 bbl of residual fuel. By 1950, 395,000,000 bbl of distillate fuel were consumed, along with 584,000,000 bbl of residuals. The growth of distillates and the drop in residuals to 1954 has been phenomenal, 527,000,000 bbl of distillates, with a drop to 522,000,000 bbl of residuals showing the inevitable downward trend.

The real story is told largely in Table 3, the *percentage* of crude devoted to the various primary products made in this country. For example, in 1920 gasoline produced was 21.7 per cent of total crude processed. In 1940, the gasoline production was 41 per cent.

In the 14 years from 1940 to 1954,

TABLE 3. Production of crude and major products, in barrels per year and in percentages of runs to stills, 1920-1954.

Year	Products crude	Gasoline Amount	Gasoline Per cent* of crude	Gas and distillate oil Amount	Gas and distillate oil Per cent* of crude	Residual fuel oil Amount	Residual fuel oil Per cent* of crude	Runs to stills
1920	453,861,000	116,251,000	21.7	—	—	—	—	535,382,000
1930	953,331,000	432,241,000	39.8	—	—	—	—	1,083,511,000
1940	1,412,081,000	598,277,000	41.1	183,304,000	12.6	316,221,000	21.8	1,457,086,000
1946	1,851,748,000	748,303,000	38.6	287,896,000	14.8	431,364,000	22.6	1,945,909,000
1947	1,988,797,000	815,825,000	41.7	312,173,000	14.5	447,795,000	20.9	2,154,280,000
1948	2,167,264,000	895,069,000	39.9	379,340,000	16.9	479,988,000	21.3	2,248,352,000
1949	1,996,699,000	938,633,000	42.0	339,530,000	15.2	424,829,000	19.0	2,237,626,000
1950	2,153,561,000	998,336,000	40.2	398,912,000	16.0	425,217,000	18.8	2,486,363,000
1951	2,450,252,000	1,108,527,000	40.6	475,801,000	17.5	469,377,000	17.2	2,723,879,000
1952	2,452,676,000	1,156,405,000	40.8	521,264,000	18.5	454,784,000	16.1	2,822,595,000
1953	2,602,394,000	1,259,040,000	43.0	532,221,000	18.3	449,979,000	15.4	2,921,912,000
1954	2,596,166,000	1,232,989,000	43.1	542,278,000	18.3	416,757,000	14.1	2,959,449,000

Percentage of RFO dropped ⅓.
Percentage of gasoline nearly constant.
Percentage of gas oil rose 50 per cent.
*(Calculated from "Runs to Stills" Figures for Percentages.)

gas and distillate oil consumption increased threefold in quantity; in percentage terms, the fraction of crude used grew from 12 to 18 per cent, a 50 per cent growth. In the same period, residual oils increased only 100,000,000 bbl, dropping from 21.8 per cent of the crude run to 14 per cent, a loss of one-third.

Future Prospects for Fuel Oils

Outstanding oil industry economists expect that distillate fuel demand, which was 1,442,000 bbl per day in 1954, will increase by nearly forty (39 per cent) per cent to 2,002,000 bbl per day by 1960. This will be about 5.6 per cent annual growth, as compared to the almost 11 per cent. For the period 1960-65, the gains are expected to be somewhat lower than 5.6. Railroads are approaching the saturation point in diesel-electric power plants, after a phenomenal growth since 1946, as shown in these figures:

	Per Cent of Rail Traffic Hauled by Diesels on Class 1 Roads.	
	1946	1954
Freight	9.7 per cent	84.1 per cent
Passenger	15.3 per cent	86.0 per cent
Switching	29.5 per cent	89.7 per cent

By 1960, railroad consumption of distillate — diesel — fuels is expected to rise only 11 per cent above that in 1954, to a total daily demand of 236,000 bbl. Home heating takes 60 per cent of our total distillate fuel production, and two main causes for increases exist: Building of new homes and conversion of old heating systems, largely coal-fired, to fuel oil. New housing is expected to continue at or above a rate of 1,200,000 starts per year until 1960, then to go higher than that; this is a more rapid climb than the 1,000,000 annual starts (new homes) since the last war. Average consumption per burner is showing a downward tendency, traceable to more efficient burners and to better insulation in a larger percentage of homes. About the only backtracking to be done in distillate fuel markets is in diesel-powered ships, where the trend to residual fuels is expected to reduce distillate consumption by some 13 per cent below 1954 figures by 1960. There again, current investigations in the use of residual fuel oil for ship's diesels may reduce this figure still further.

Residuals to Quit Railroading

Only two chances appear to exist to keep any appreciable amount of heavy fuel in locomotive tanks; some engineering executives believe that residual may become an important part of diesel fuel supply, and some testing is being done with residual distillate blends in diesel-electrics. Also, gas turbines seem to be coming into their own as railroad prime movers. Three years of experimentation by Ruston & Hornsby, Ltd., for Esso Development, Ltd., in England with various types of residual fuels containing differing amounts of sulfur up to 3.5 per cent and metals and total ash up to 300 parts per million and using a magnesium additive reduce corrosion and solids deposition on the turbine blading. After a 1000-hr test run, the blades were adjudged fit to continue in service; mean gas temperature was about 700 C (1292 F). Fuel savings are expected to parallel those mentioned for ship's diesels above.

Strange or not, bunker fuel consumption is expected to go up during the next several years, to rise from 299,000 bbl per day in 1954 to 348,000 bbl per day in 1960. Currently, ship builders prefer residual-fueled ships to diesel-powered vessels, a definite change in their ideas from several years ago. Prospective increases in the volume of shipping and of marine transportation will add still more demand for residuals, authorities say. Therefore, two factors will work to increase residual consumption in bunkers: Conversion of diesels to residual fuels, and new fuel oil-steam ships built to meet transportation demand increases.

TABLE 5. Percentage refinery yields of distillate and residual fuel oil.**

Year	Distillate fuel	Residual fuel
1941	13.42%	24.30%
1946	16.62	24.91
1947	16.84	24.16
1948	18.56	23.48
1949	17.44	21.74
1950	18.98	20.23
1951	19.97	19.71
1952	21.18	18.56
1953	20.67	17.61
1954	21.29	16.36
1st 8 months 1954	20.71	16.68
1st 8 months 1955	22.05	15.32

Source: American Petroleum Institute.

These data are shown graphically in Fig. 1 and 2. Note that for residuals, consumption increases for vessels, heating, gas and electric plants, and industrial uses parallel the drop in railroad consumption. For distillates, heating and range oils show the highest gain, with vessels showing little change, and gas and electric plants beginning to pinch out.

Regarding the situation abroad, the British Transport Commission ordered (December, '55) 141 diesel locomotives, along with 30 power units to be installed in locomotives to be built in the commission's own workshops; cost of this order £10,000,000 ($28,000,000). Eventually modernization programs will bring on 2500 main-line diesels, costing £125,000,000. It is not difficult to see that the new British refining capacity will have a growing market for either distillate or residual diesel

TABLE 4. Heating value of gases and fuel oils.*

Products petroleum	Btu/lb	Btu/gal	Pure hydrocarbons	Btu per lb vapor	Natural and manufactured gas	Btu per Mcf
LPG	—	95,500	Methane—CH_4	23,920	Wet Nat. Gas Av.	1075
Aviation gasoline	20,440	120,200	Ethane—C_2H_6	22,350	Dry	1970
Motor gasoline	20,282	124,240	Propane—C_3H_8	21,690	West Virginia	—
Kerosine	19,900	135,000	I-Butane—i-C_4H_{10}	21,290	Pennsylvania	1350
			N-Butane—n-C_4H_{10}	21,340	Oklahoma	1064
			I-Pentane—i-C_5H_{12}	21,060	California	1053
			N-Pentane—n-C_5H_{12}	21,120	Ohio	946
District No. 1	19,200	136,000	N-Hexane—n-C_6H_{14}	20,970	Texas	698–988
District No. 2	—	138,500	N-Heptane—n-C_7H_{16}	20,860	—	—
District No. 4	—	145,000	N-Octane—n-C_8H_{18}	20,780	Manufactured: Av.	540
					Blast Furance Gas	92
Residual fuel oil av.	—	149,700	N-Nonane—n-C_9H_{20}	20,710	Blue (Water) Gas	285
Residual fuel oil No. 5	—	148,500	—	—	Carbureted (Water) Gas	529
Residual fuel oil No. 6	—	152,000..	N-Decane—n-$C_{10}H_{22}$	20,660	Coal Gas	560
					Coke Oven Gas	476
Residuum	—	152,000	—	—	Oil, Gas	461
					Producer Gas	133–153
Acid sludge	—	107,000	—	—	Refinery Gas	1500
Crude Petroleum	—	138,100	—	—	—	—
Ranges from Pennsylvania	—	132,200	—	—	—	—
to Mexico	—	152,000	—	—	—	—

*Eugene Ayres — Energy Sources.

fuels. This is all the more surprising in Britain, traditionally a coal-burning country.

Another large variable in the residual fuel situation — imports. For years, an increasingly sanguine battle royal has been carried on between importers of crude and heavy fuels, and U. S. domestic crude producers, who wish to limit imports to lead the industry to process more domestic crude. So far voluntary cutbacks have been urged on importers. The current economics of the situation is all in favor of importing both crude and fuel oil — lower prices. To import heavy fuel oil means that American crude can be utilized more nearly completely to make higher priced products; the imported fuel, made from less expensive crude, can be sold at a price lower than can fuel from domestic crudes.

Authorities say that if the cheaper imported fuel oil is permitted to enter this country without any more restriction than is now placed on it, the price of heavy fuel may be held down, to boost its use in many applications. If imports are reduced sharply, then more American crude must yield residuals, price must rise and thus some uses of residual may find its further use uneconomic. In the last analysis, use of residual fuel is dictated entirely or largely by economic considerations — price. So long as one product is sold at a price lower than the cost of the raw material, the tendency will be to eliminate or minimize the making of this uneconomic product. Imports of residual fuel oils in 1955 amounted to 146,000,000 bbl, an increase of 10 per cent over 1954, figures that show how the market is trending as of the present.

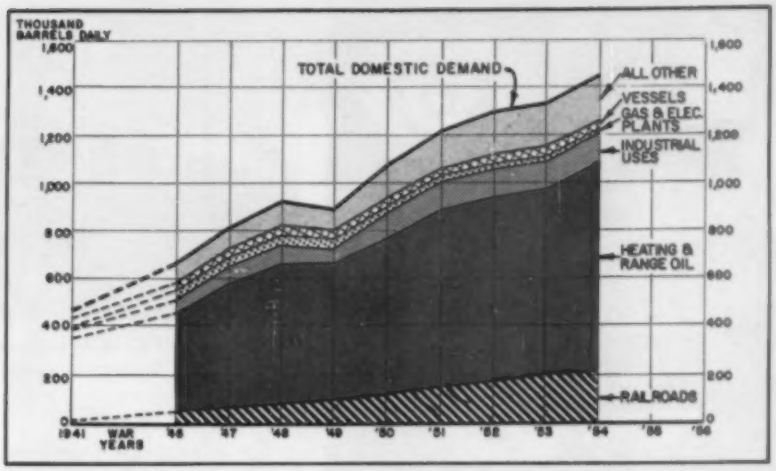


FIG. 1. Domestic demand for distillate fuels, 1946-54.

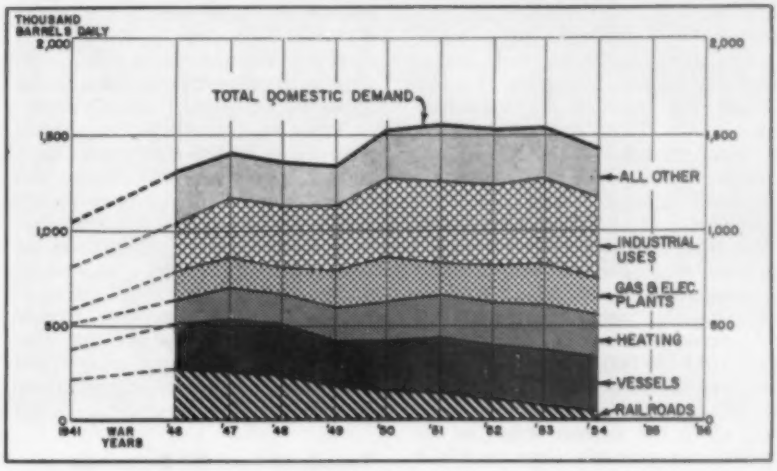


FIG. 2. Domestic demand for residual fuels, 1946-54.

What the Refiner Can Do

In these days of strenuous effort to make each drop of crude carry its own part of the refinery load, several routines may be followed in realizing the most from heavy residues. Among these methods are:

1. Atmospheric distillation to, say, 30 per cent bottoms on the crude — varies with each type of crude and the refiner's purpose — followed by vacuum distillation for two-thirds of vacuum charge overhead, bottoms 10 per cent of original crude.

2. Vacuum tar bottoms may be run to gas, overhead distillate and coke, by any of the coking methods — fluid, delayed, thermal cracking to coke, etc.

3. Vacuum overhead is good cat-cracker charge stock, may be enough to double the percentage of cracking stock per barrel of crude. It can be used also as domestic heating oil, especially when blended with a smaller amount of straight-run gas oil, or by employing additives to offset the undesirable properties of the unsaturated hydrocarbons that are present inevitably — sludging, burner plugging, poor burning qualities, etc.

4. Vacuum bottoms may be made into road oil or asphalt by the use of the customary reducing, blowing, oxidizing equipment. In case this route is selected, enough vacuum bottoms must be available in the plant to make asphalt manufacture economically feasible.

5. Vacuum overhead is also excellent gas turbine fuel, we are told, being low in objectionable metals and comparatively low in sulfur. This overhead is very valuable when a unit is doing much recycling. If little recycle is employed, its value is somewhat less. It should be used with a relatively sulfur-resistant catalyst, one nearly free of iron, operators say.

6. Then we have the special processes, such as Texaco's hydrogen production from heavy residues. The Houdresid process announced last year is to make gasoline and heavier stocks from heavy oils. We have, too, hydrodesulfurization, hydroforming and hydrofining, but actually we have no practicable direct hydrogenation process now in operation on any large scale.

If we consider the routine of vacuum reduction of atmospheric bottoms (30 per cent) to 10 per cent (on crude) heavy bottoms and the coking of this bottoms with such overhead liquid and gas as may be yielded, the change in the gas oil-cat cracker charge picture will be changed as follows, starting with the 417,000,000 bbl of residual fuel made in 1954. Assuming for convenience a 60 per cent overhead on the vacuum operation, this yields 250,000,000 bbl of gas-oil, usable for practically any purpose for which gas-oil is suited. Coking the heavy vacuum residuum, assumed to be one-third of the vacuum unit charge of 139,000,000 bbl, we can recover theoretically about one-fourth of it, 35,000,000 bbl, as

FIG. 3. Inspecting a 6-ton marine diesel piston, after burning 50,000 bbl of residual fuel.

FIG. 4. Experimental General Electric gas turbine-electric locomotive under road test.

cracked gasoline; 50 to 60 per cent of it as heavy gas oil, 70,000,000 to 83,000,000 bbl. The coke yield varies widely, depending on the crude source, and may be anywhere from 15 to 30 weight per cent of the immediate charge.

This 250,000,000 bbl of distillate fuel oil from vacuum, plus 70,000,000 from coking, would have increased the total distillate fuel yield for 1954 to 860,000,000 bbl. If the entire overhead heavier than gasoline were cracked catalytically with, for example, a 50 per cent gasoline yield, the 320,000,000 bbl would have added to our motor fuel yield 160,000,000 bbl, with a like amount added to cat-cracked gas-oil or recycle stock. Handling *all* the residual oil in this manner would be impracticable, probably, since much of it would not prove economical to so convert, but the empirical calculation shows what *could* be done.

Calculating costs and returns on one system for coking (Fluid) for which data are available, total charges for stock price and unit operating costs range from $1 to $1.50 per barrel. Gross return per barrel of charge stock is given as $2.63 to $2.12, or a net gain of $1.14 and $1.13, from two entirely different types of crude residue.

Disposal of the coke made depends on the quality. High-sulfur cokes are fuel cokes and in most calculations are priced at $5 per ton. Low-sulfur cokes are suitable for electrodes for electric furnaces, etc., and bring twice that price.

Value of the light hydrocarbons as by-products of coking will depend entirely on the specific situation in each installation. High in olefins, these gases if in a refinery location where the same plant is making petrochemicals or where an adjacent unit is making petrochemical products, these gases find ready use and have premium value. Much of the ethylene and propylene now being made and going into polyethylene and many other new products is derived from refinery "waste" gases from cracking and coking stills.

Impetus appears to be given to the utilization of residual coke as industrial fuel by the development recently of a system for pulverizing coke, incidentally from the Fluid process, and transporting it via a stream of air into the burner, installed in a cement drying (clinkering) kiln. Preliminary results indicate this to be a satisfactory and economical fuel for this and other uses such as steam boilers, etc. (Kaiser System). It is obvious also that coke derived from petroleum can be burned via stokers in the same manner as coal or coal-derived coke.

Trends in Fuel Oil Demands

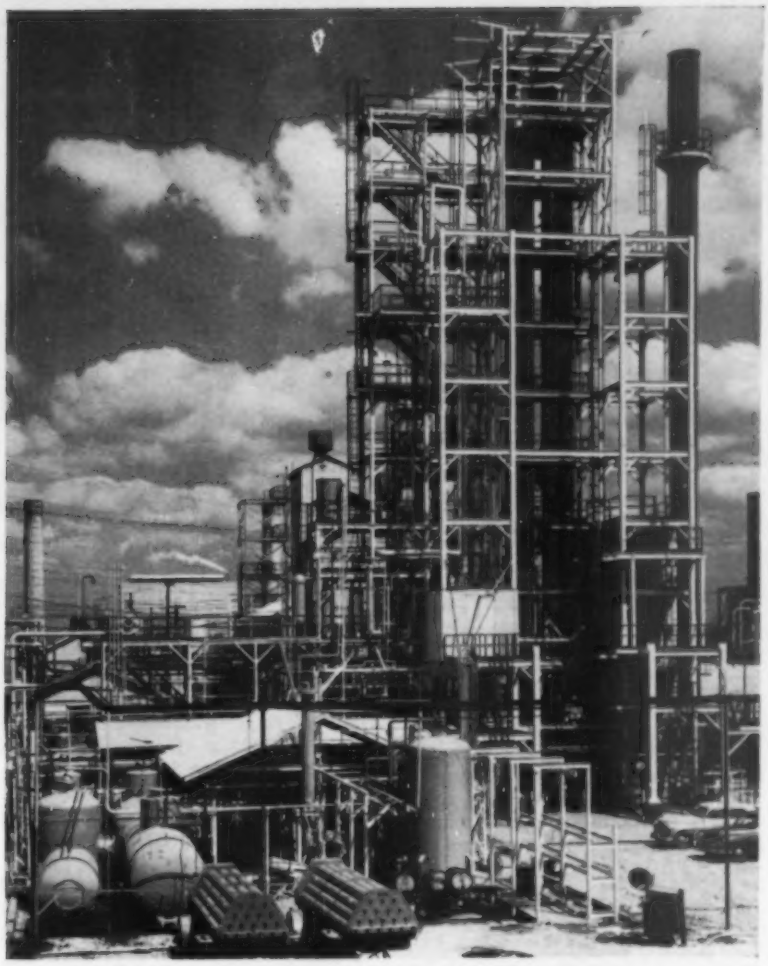
In reference to Fig. 1 and 2, it is interesting to note the obviousness of the trends shown therein. The graphs showing the growth in railroad distillate fuel consumption and the shrinking in residual fuel demand are practically mirror images of each other. Heating oil demand for distillates more than doubled between 1946 and 1954. Residuals for heating increased by only 60 per cent. Marine consumption (vessels) rose by 60,000,000 bbl, or 25 per cent. At the same time only 33,500,000 bbl of distillates were consumed for vessels in 1946, increased by less than one-third in 1954, to 42,600,000 bbl. Recent developments indicate that marine consumption of heavy fuels may increase, due to a growing preference for residuals both for steam production and for use in diesel engines aboard ships. Miscellaneous demands for distillate fuels are increasing but slowly, although on the upgrade; whereas for residuals, the needs fell some 30,000,000 bbl, or 11 per cent of the 1946 consumption.

Summarizing this brief presentation of data on the refining and especially the fuel oil situation in the petroleum industry, it appears that whatever the demand development for residuals as end products, the need for increasing amounts of cat-cracker charge and for distillate fuel oils, which is inevitable, will pinch residuals down to smaller and smaller amounts. Demands for residuals in locomotive and ship's power plants, possibly or probably in gas turbines, and for any other uses may slow the decline in total heavy fuel consumption, but will not stop the trend nor reverse it in the foreseeable future. Since both gross and net value of the distillate fuels, from gasoline to heavy gas oil, are greater than for residuals, those higher priced fuels can be expected to take precedence over the heavy material.

Therefore, the expectation is that the industry will require, and use, more coking units in the near future. In fact, a half-dozen such units using various processes were completed recently, are building or are on the design boards. More are expected, say those in the know.

Since economics is the overruling factor in residual fuel uses, and since American crudes are higher priced than comparable quality crudes produced abroad, the pressure to increase imports of both foreign crudes and residuals may be expected to become heavier as times goes on. Pressure brought on Congress by domestic producers to limit imports will tend to increase domestic production. It will tend also to raise the price of residual fuels, made from more expensive crudes, which trend in turn will have the effect of crowding residual fuels out of uses where the advantage is purely economic and price-wise.

What the algebraic sum of these effects will be in the foreseeable future is on the lap of the political and economic gods. ★ ★ ★



Large pilot plant for the study of cracking and reforming catalysts and their behavior in refining operations, at Esso Research Laboratories in Baton Rouge, Louisiana.

Advancements in fundamental knowledge keep pace with practical technology

Recent Progress in Petroleum Conversion Catalysts

Vanderveer Voorhees
Consulting Chemical Engineer

TREMENDOUS strides in the use of catalysts in petroleum refining naturally focus attention on the composition of the catalysts themselves, but this is a subject about which little is said when petroleum engineers get together to discuss their new processes. Catalysts are used for many purposes, such as hydrogenation, dehydrogenation, Fischer synthesis, polymerization, etc., but conversion catalysts can be considered as those in which only hydrocarbons are involved and the carbon skeleton is altered. This would include catalysts employed in cracking reforming, hydroforming, polymerization and similar processes.

EXCLUSIVE

Probably the most significant development in recent years in conversion catalysts lies in the direction of incorporating small amounts of modifying elements into the established silica-alumina, silica-magnina, or other mixture of oxides of Group 2, 3 and 4 metals. The modifying element is usually one that has strong hydrogenating activity such as platinum, nickel or molybdenum. The field for such three component catalysts is quite extensive, and we may expect further developments in this direction.

Platinum Catalysts

Perhaps the best known catalyst of this type is active alumina with .01 to 0.5 per cent of platinum. A small amount of fluoride appears to stabilize the platinum, possibly by preventing change in crystal structure. The activity of platinum in effecting hydrogen transfer makes these catalysts valuable in aromatization of cyclo paraffins. Cost of platinum has militated against the use of large amounts of this metal, but recently the Universal Oil Products Company has announced its Type R-8

"Platforming" catalyst in which the amount of platinum is increased. Since the platinum is always recovered from the spent catalyst, the added cost is largely one of investment, but this can be quite large. At $94 per troy ounce, the current market price of platinum, a dollar's worth of platinum per pound of catalyst is only .0735 per cent.

Thomas[1] reactivates a platinum on alumina catalyst by burning off carbon, then treating with nitrosylchloride vapor at ordinary temperature. Appell[2] found that a catalyst containing 0.3 per cent Pt; 0.12 per cent F and 0.45 per cent Cl on Al_2O_3 became deactivated by traces of iron too small to determine by emission spectrum, but strong acid extraction restored catalyst activity.

J. G. Leopard[3] found that hot spots in the catalyst bed changed the active gamma to inactive alpha Al_2O_3. Treatment with acid removes part of the Al_2O_3 leaving platinum in the insoluble residue from which remaining Al_2O_3 is extracted with strong caustic solution.

Haensel and Schmerling[4] describe depositing .01 to 1 per cent platinum on Al_2O_3 prepared from gamma alumina by treating with an organic acid to make the basic salt, which is then ignited. Somewhat related is a catalyst made by Oblad[6] by leaching active Al_2O_3 with acid to remove less than 10 per cent, then calcine and impregnate with H_2PtCl_6.

The effect of halogens in activating platinum catalyst was shown by Pines & Ipatieff[6] where alkyl chlorides were added to cycloparaffins to promote conversion to aromatics. An 85 per cent yield of toluene was obtained from ethyl cyclopentane at 300-400 C with active Al_2O_3 impregnated with chlorplatinic acid.

Fundamental Studies of Surface Catalysis

In a recent survey of catalysis, Oblad[7] points out the need for more basic knowledge of the surface chemistry of catalyst, adsorption, desorption, etc. Some interesting work along this line has been reported by Holt & King[8] on the solubility of SiO_2 in water. Pure silica from combustion of silane or purified gel was soluble to the extent of 10-14 mg/100cc at 25C, whereas quartz dust dissolved only to the extent of 1.6 mg even after 50 days' shaking. The rate of solution of quartz was initially high but fell off rapidly, indicating a surface layer of strained particles. Tracer studies showed a difference in the nature of the surface layer, suggesting an incomplete monolayer.

A study of Al_2O_3 films formed on aluminum by anodizing (CR_2O_3 bath)

X-Ray machine employed in research for the analysis of catalysts.

by Giles[9] showed that pure alpha alumina absorbs anionic but not cationic compounds. This method may be useful in studying catalysts in which Al_2O_3 is the support. The surface area of $Mg(OH)_2$ gel was found to increase when calcined at 400-500 C, reaching a maximum, then decreasing, apparently as a result of sintering, according to two papers by Gregg, Packer and Wheatley.[10] The presence of sulfate shifted the adsorption isotherm in the direction of higher temperatures.

Plank and Nace[11] used the dealkylation of cumene to determine activity of cracking catalysts and discovered that small amounts of impurities in the cumene largely influenced the results by accelerating coke formation. Nitrogen compounds, styrene, cumene hydroperoxide, etc. inhibited cracking by competing for the active catalyst centers.

Several investigators have sought to correlate electrical conductivity with catalyst activity with partial success. Weller and Voltz[12] found no simple relationship between activity and conductivity of chromic oxide in hydrogenation of ethylene, whereas Heckelsberg et al[13] found conductivity of zinc oxide to vary with activity in the HD exchange reaction. Pretreatment with hydrogen appears to release zinc atoms that diffuse into the lattice, leaving surface defects essential for catalytic activity. High-energy X-rays had no effect. Weisz et al[14] found that electrical conductivity of SiO_2-Al_2O_3 cracking catalysts was nearly proportional to residual sodium content. Strangely enough, potassium had little or no effect on conductivity.

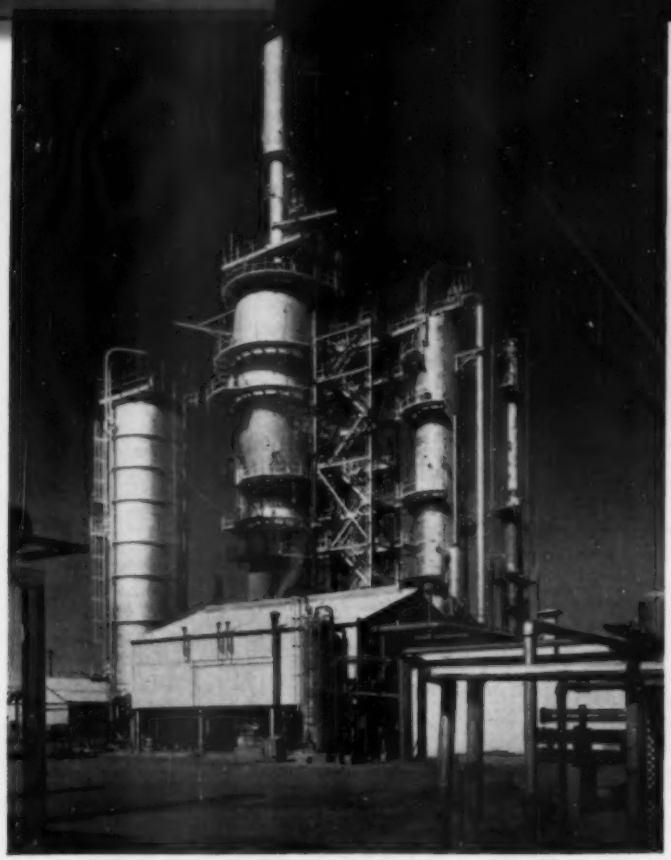
Hydrogen exchange in saturated hydrocarbons was studied by the deuterium exchange reaction over nickel at 130 to 210 C.[15] The alkane is adsorbed on the nickel, then migrates, exchange taking place with each migration. Two substituents on a carbon atom block the migration. Winter[23] studied the reaction: $CO + O = CO_2$ over NiO, Cr_2O_3 and Cu_2O, using[18] O as a tracer. He found, in case of Ni and Cr that the reaction proceeds on only about 2.5 per cent of the surface by an exchange mechanism. With copper, however, the reaction involved 10 to 40 per cent of the surface without exchange of oxygen with the catalyst. Jenkins and Rideal[24] showed ethylene to be dissociated by nickel surfaces to chemisorbed acetylene and hydrogen, which could be removed by ethylene to form ethane.

Surface properties of precipitated Al_2O_3 were studied by Harris and Sing.[16] Precipitates from the chloride in an acetate buffered solution had surface areas as high as 400 M^2/gm, whereas the maximum for activated alumina is about 300 M^2/gm. The pore diameter of gels, eg: SiO_2-Al_2O_3, is increased, according to Plank et al[7] by heating the hydrogel under pressure. Diameter was increased from 50 to 630 Å when heated at 600 F and 1500 psi.

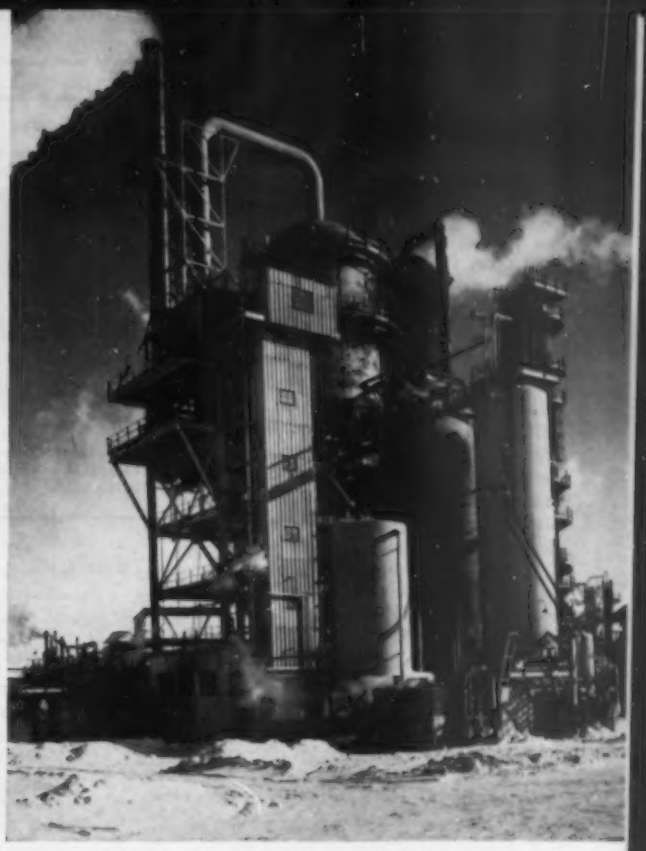
Catalyst Poisons

A discussion of catalyst poisons at the St. Louis, Missouri, meeting of the American Petroleum Institute in May, 1955,[18] emphasized the need for better analytical methods for trace elements, particularly nickel, vanadium and nitrogen. Reference has already been made to the striking effect of traces of iron in a platinum catalyst.[2]

Stine[19] restores iron poisoned cracking catalyst by adding beryllium, eg: less than 1 per cent beryllium nitrate. Smith[20] restores a silica cracking cata-



Medium-sized (Orthoflow) catalytic cracker now in service (Champlin Refining Company).



Typical fluid catalytic cracking unit (British-American) where hundreds of tons of catalyst are used in producing motor fuel.

lyst containing traces of nickel, eg: .006 per cent, by treating it with acetyl acetone, which deactivates the nickel, possibly by forming an inactive chelation complex. Plank[21] reactivates a silica cracking catalyst containing traces of nickel by washing with dilute acid, then steaming at 1000-1300 F. Sweetser[22] reactivates silica catalyst with 0.5 per cent fluosilicic acid.

Polymerization Catalysts

Silico tungstic acid on a carrier was found to be an excellent catalyst for propylene polymerization.[25] Bauxite impregnated with 20 per cent of the heteropoly acid was dried at 100-300 C and employed at 150-180 C. The yield of tetramer is about twice that obtained with conventional phosphoric acid-silica catalyst. No water injection is required and plugging of the catalyst bed is minimized. At 100 atm pressure, 95 per cent conversion to liquid products can be obtained with catalyst life of 50 gal/lb.

A silica-alumina-nickel oxide catalyst containing 4 per cent Ni polymerizes ethylene in presence of H_2 at 300 psi and 100 F. The product was 50 per cent butenes, the rest being C_6 and heavier olefins.[26] Addition to 1 to 3 per cent of cobalt to a phosphoric acid-diatomaceous earth catalyst increases activity and also crushing strength.[27]

Morrell[28] adds small amounts of Zn, Cd or Mg to H_3PO_4 on kaolin. Other modifications of phosphoric acid catalysts are shown in recent patents.[29]

Aromatization Catalysts

Brown and Martin[30] passed the entire product gas from Fischer synthesis over molybdenum and chromium on alumina at 600 C, producing 7.4 per cent benzene. When vanadium was included in the catalyst, the yield of benzene increased to 28 to 38 per cent, with toluene 31 per cent. Precipitated Al_2O_3 with 10 per cent MoO_3 and 3 per cent NiO is effective for purifying benzene at 180-450 C in presence of hydrogen. Sulfur does not affect it.[31] Isomerization of mixed xylenes over Al_2O_3-SiO_2 gel activated with fluorine or silicon tetra fluoride yields paraxylene at 400-500 C. After freezing out the para isomer, the remaining xylenes are fractionated out and recycled, benzene, toluene and tetra methyl benzene being eliminated.[32]

Dual-function catalysts that combine cracking and aromatization are of growing interest. A Badische patent[33] describes cracking gas-oil over silica-alumina promoted with MoO_3, Mg, Fe or Zn. Yields of 50-60 per cent per pass of 70-octane gasoline are obtained at 200-700 atm and 390-460 C. Ammonium molybdate is applied to the sintered Al_2O_3-SiO_2 pellets to prepare the catalyst. A similar dual-function catalyst is described by Oblad[34] employing at least 70 per cent SiO_2 with Al_2O_3 and MoO_3. With 0.6 per cent MoO_3 the gasoline had an octane number of 65.4 CFRM, whereas at 2.1 per cent MoO_3 it was 73.5 CFRM.

A similar catalyst was found by Ciapetta and Hunter[35] to convert aromatics to cyclo-paraffins with equal facility. SiO_2-Al_2O_3 modified by Ni, Co, Pt, nickel tungstate, molybdate, phosphate, chromate or borate, V_2O_5 or copper chromite converted benzene to methylcyclopentane at 600-750 F in presence of 4 to 6 mols of hydrogen.

Catalyst Preparation

Efforts continue to be made to increase heat stability of magnesia-silica cracking catalysts. J. E. Ahlberg et al[36] heats the dried gel with water at 100-212 F for 6-18 hr. Pardee[37] prepared a magnesium-calcium silicate from $CaSiO_3$ and $MgCl_2$, then activated with steam at 400-500 F for 20 to 60 min. Hunter[38] was able to reduce the coke formation on a silica-magnesia catalyst about 10 per cent by adding 0.25 per cent NH_3 to the feed stock, especially with high-sulfur stocks.

The role of the alkali metals in catalysis has received more attention. As already mentioned,[14] electrical conduc-

tivity of SiO_2-Al_2O_3 catalyst was affected by sodium but not by potassium. Starr[39] treated a synthetic alumina-gel cracking catalyst containing 0.5 to 1 per cent Na_2O, with HF to increase activity. From 0.3 to 0.7 per cent HF was passed through the catalyst at 1000-1100 F, followed by soaking at 1050-1150 F for several days.

That the alkali metal may form hydrocarbon complexes on the catalyst surface is suggested by the work of Holmes, Walker & Ubbelohde,[40] who prepared complexes of Na, Li and K with anthracene that appeared to result from electron transfer between the metal and the hydrocarbon molecule. Solvent-free complexes are semi-conductors. The ethylation of toluene in the side chain, with ethylene at 200-325 F over sodium metal activated such compounds as alcohol, anthracene or chlortoluene, is shown in patent of Pines and Ipatieff.[41] A yield of 71 per cent n-propyl benzene based on 48 per cent toluene reacting is claimed.

Sulfide catalysts are described in three recent patents.[42] De Rosset used molten sulfides of 5th group elements as cracking catalysts. Garwood co-gelled Cr_2O_3-Al_2O_3, reduced with H_2 at 750 to 1100 F and contacted with H_2S. Johnson et al regenerated a MoS_2 hydrogenation catalyst by burning at 300-500 F, then treating with NH_3 to form ammonium molybdate in situ, followed by H_2S to restore the MoS_2.

McKinley & Kline[43] make a hydro-isomerization catalyst from MoO_2 by partial reduction to the metal, then surface oxidizing with air, CO_2 or steam to remake the oxide. N-heptane is isomerized by this catalyst to 35-40 octane number, CFR-Res. Adams & Kimberlin[44] reform virgin light naphtha over active carbon, then reactivate with air, CO_2 or steam at 1200-2000 F. Sieg and Wellman[45] dehydrogenate hydrocarbons from ethane to octane over alumina-beryllia activated with 15 to 20 per cent of Cr_2O_3 or MoO_3. Butane gave 50 per cent butylene and 15 per cent butadiene at 1100 F.

Kimberlin at Esso Research patented[46] a noval method of making an alumina catalyst by which an aluminum alkylate is made from the metal and an alcohol, then mixed with a water solution of boric acid, ammonium molybdate, tungstate, etc., with hydrolysis and simultaneous impregnation. Ahlberg and Cox[47] decomposed feldspars with caustic at 500-800 F, then gelled the SiO_2 with acid and precipitated the Al_2O_3 with a suitable base to yield a silica-alumina cracking catalyst. C. C. Legal[48] prepares a SiO_2 sol, forms the gel, then washes it free from salts and hardens by heating under pressure.

Details are given by McKinley & Pardee[49] for preparing a nickel-tungsten catalyst from ammonium meta tungstate and a nickel salt deposited on a carrier such as microspherical alumina-silica. The pH of the tungstate solution is held between 2 and 5 to avoid precipitation. Ashley[50] treats silica hydrogel with aluminum sulfate, precipitates Al_2O_3 with ammonia and washes to remove salts. The pH is then adjusted to 6.1 to 6.5 with ammonia to remove sulfate ion, thus effecting more complete removal of salts in the two stages. Better physical properties are imparted to a silica catalyst by co-gelling SiO_2 sol with a metal salt and an oxide sol, such as the oxides of Al, Mg, Zr, Be, Va, Th, Ta. Adding SiO_2 sol to Al_2O_3 sol and $Al_2(SO_4)_2$ gave a gel with improved strength to resist attrition and shattering.

In conclusion, it is only fair to say that the above review shows something of the trend in catalyst development, but can hardly be complete because of the large amount of work being done in the field. For example, it does not show the steps being taken to protect catalysts from deterioration by purification of feed stocks, etc., or combination processes such as proposed by Oblad[52] in which hydrogenative cracking over SiO_2-Al_2O_3-NiO produces a naphtha particularly adapted for aromatization over a platinum catalyst. Future work appears to be directed toward a study of trace elements, both promoters and inhibitors, the goal being indefinite catalyst life and reduction in maintenance cost. The widespread use of platinum catalysts is clear evidence that the ceiling on catalyst cost can be high if maintenance and losses are low.

Importance of physical strength in catalysts is again brought to focus by work recently reported by Kinsella & Mitchell,[53] who tagged a silica-alumina catalyst with radio cobalt and followed its course through a Fluid catalyst cracking unit. The results confirmed what had long been suspected, that freshly added catalyst was lost from the unit at a higher rate owing to the greater resistance to attrition of the older catalyst in the unit.

The Author

Dr. Vanderveer Voorhees is eminently qualified by his long training and experience to discuss the recent advances in the preparation and use of catalysts and catalysis in the petroleum refining and petrochemical industries. Chemical engineer and patent attorney with many years experience in the refinery and research laboratory, he is now a consulting engineer and patent attorney to the industry.

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MECHANICAL ENGINEERING

Mechanical Design of Processed Tubular Heaters

Part 1.

L. A. Mekler

Consulting Engineer

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BASIC problem of good mechanical design of process tubular heaters is the selection and arrangement of materials and equipment for the structural components of a heater that will meet the process requirements and, when properly installed and operated, will have the lowest total processing cost per unit charge, or per operating day at constant charge, *during the useful life of the heater.*

Total processing cost is determined by three main factors:

1. Fixed charges on the investment, consisting of depreciation and obsolescence, interest, insurance and local taxes, usually expressed as percentages of the original cost. Depreciation and obsolescence are the largest components of fixed charges and, depending on the process, may vary from 10 to 20 per cent of the original cost.

2. Maintenance and repairs. In properly designed and operated heaters, normal maintenance and repairs are a relatively minor item and seldom exceed 4 per cent of the original cost of the heater. However, if the heater is underdesigned, so that it has to be forced to obtain the desired throughput, or if portions of the heater are subjected to more severe operating conditions than contemplated in the design, the cost of maintenance and repairs may be many times the normal. If abnormal repairs and replacements require extra shut-downs, the loss of operating profits during these shut-downs must be added to the cost of maintenance and repairs.

3. Operating costs. The most important item of operating cost is the cost of fuel. With fuel oil, the fuel cost must include the cost of pumping, preheating and atomizing. If forced or induced draft is used, the power required to operate the fans must also be included in the cost of fuel handling. The other two items of operating cost are power and labor. The cost of power required to force the charge through the coil, is significant only in heaters with high operating pressure and pressure drop. Operating labor in a modern, well instrumented heater is almost negligible.

The three components of the total processing cost are interchangeable to a certain extent. Generally, a heater designed on a conservative basis as to capacity, so that it operates at mild conditions, and built of materials better than the minimum quality necessary to meet the processing requirements, will have higher fixed charges but a lower maintenance cost that a cheaper heater designed for maximum permissible rates and with materials of minimum quality. Similarly, a heater designed for 60 per cent thermal efficiency will cost less and have lower fixed charges but higher fuel costs than a heater for the same service with a higher thermal efficiency. The lowest total cost of processing is obtained in a heater with the lowest sum of the three components of the cost. There is a break-even point between the cost of the heater and processing cost where the fixed charges on the additional cost of the heater are higher than the additional savings in maintenance and operating costs obtained in the more expensive heater.

Table 1 shows the relationship between fixed charges fuel cost and total operating cost of heaters for the same service but with different thermal efficiencies. With a fuel value of 15 cents per million Btu,LHV, heater C is the most economical and heaters D and E are not justified. However, if the temperature of the charge at the inlet to the heater is considerably higher than that assumed for the table, so that the efficiency obtained with heater C II is 77 instead of 80 per cent, and if the fuel is worth 35 cents per million, or approximately $2.25 per barrel (not unusual in some localities in the U. S. A. and quite common abroad), the savings, Item 12, with heaters D and E would be greater than with heater C, so that heaters D and E would be justified.

Relationships between the component of total processing costs in Table 1 are for a heater processing a noncorrosive charge. With a corrosive charge producing corrosion

TABLE 1. Comparative total cost of processing with different types of heaters.

All Heaters: Feed 15,000 B.P.D.; Heat Load 50 MM Btu/hr; Fuel 15 cents/M Btu; Operating Time 8,000 hr/year

		A	B	C	D	E
Heater Type		All Radiant	Integral Convect.	Separate Convect.	As CII with Air Preheater	As BII with Air Preheater
Tubes and Heaters		Carbon Steel Throughout				
Radiant Rates						
(1) Btu/sq ft	I	12,000	12,000	12,000	12,000	—
	II	12,000	11,000	10,000	10,000	11,000
(2) Cost, Dollars	I	69,000	74,000	87,000	—	—
	II	69,000	78,000	100,000	145,000	138,000
(3) Efficiency % LHV	I	65.0	73.0	77.0	—	—
	II	65.0	75.0	80.0	86.0	86.0
(4) Fuel Consump. MM/Btu/hr,LHV	I	77.0	68.5	65.0	—	—
	II	77.0	66.7	62.5	58.0	58.0
(5) Fuel Cost $/hr	I	11.55	10.28	9.75	—	—
	II	11.55	10.00	9.38	8.70	8.70
(6) Fixed Changes 13% of (2) $/hr	I	1.12	1.20	1.41	—	—
	II	1.12	1.27	1.62	2.50	2.24
(7) Normal Repair and Maint.	I	3% of (2)	3% of (2)	3% of (2)	—	—
	II	3%	2.75%	2.5%	—	—
(8) (7)-$/hr	I	0.25	0.27	0.33	—	—
	II	0.25	0.27	0.30	0.52*	0.53†
(9) Operating Labor				Same for All		
(10) Utilities				Same for All	0.80‡	0.80‡
(11) Total Cost $/hr	I	12.92	11.75	11.49	—	—
	II	12.92	11.54	11.30	12.52	12.27
(12) Savings, $, during useful life above	II	0	93,800	114,500	—	—
	(11) I	0	110,500	129,500	32,000	32,500

*3.25% of cost of Preheater
2.5% of cost of Heater
†3.5% of cost of Preheater
2.75% of cost of Heater
‡Additional power for Fans and Preheater

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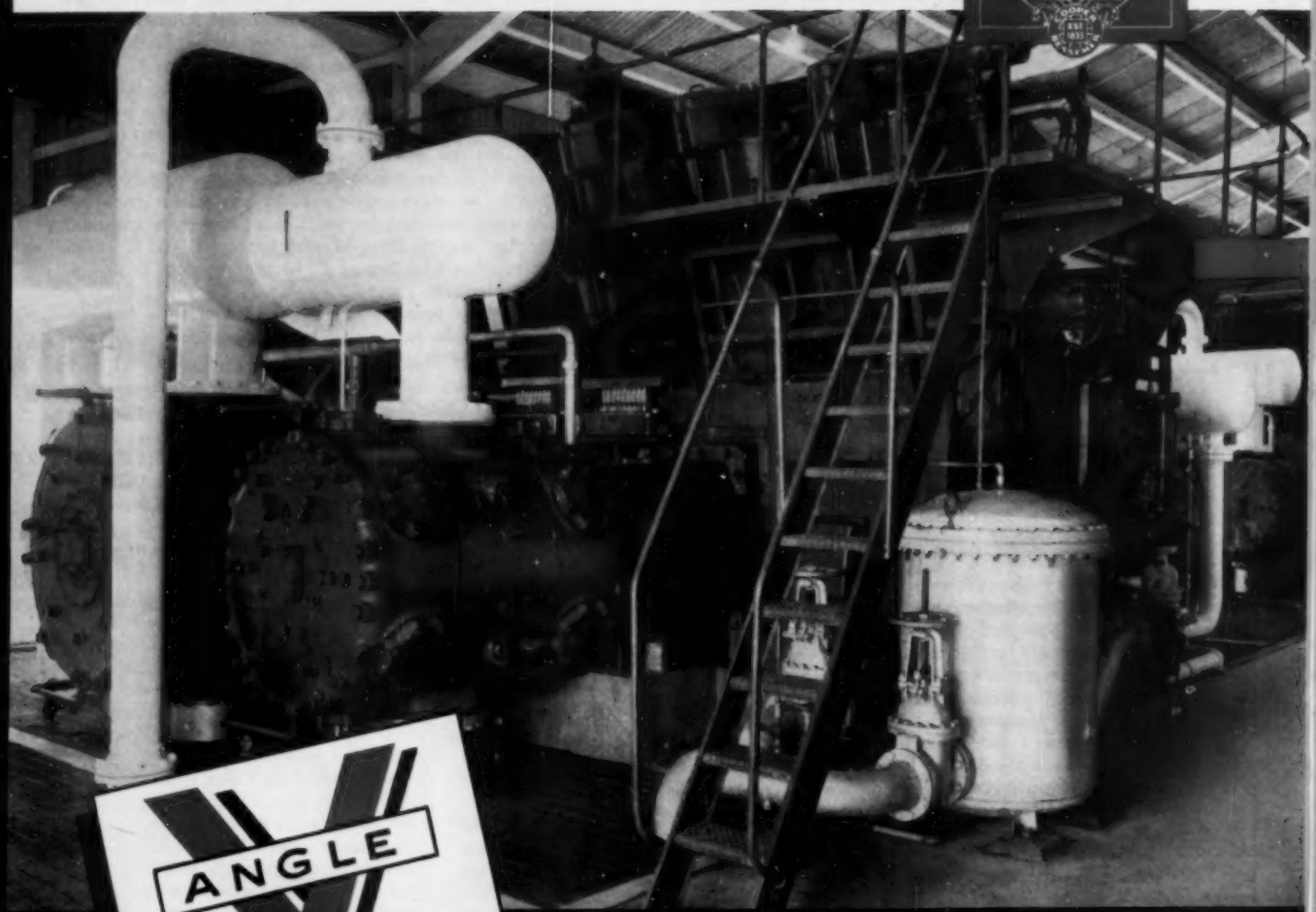

ANGLE V

Compressors

New York City Washington, D. C. New Orleans Los Angeles and San Francisco
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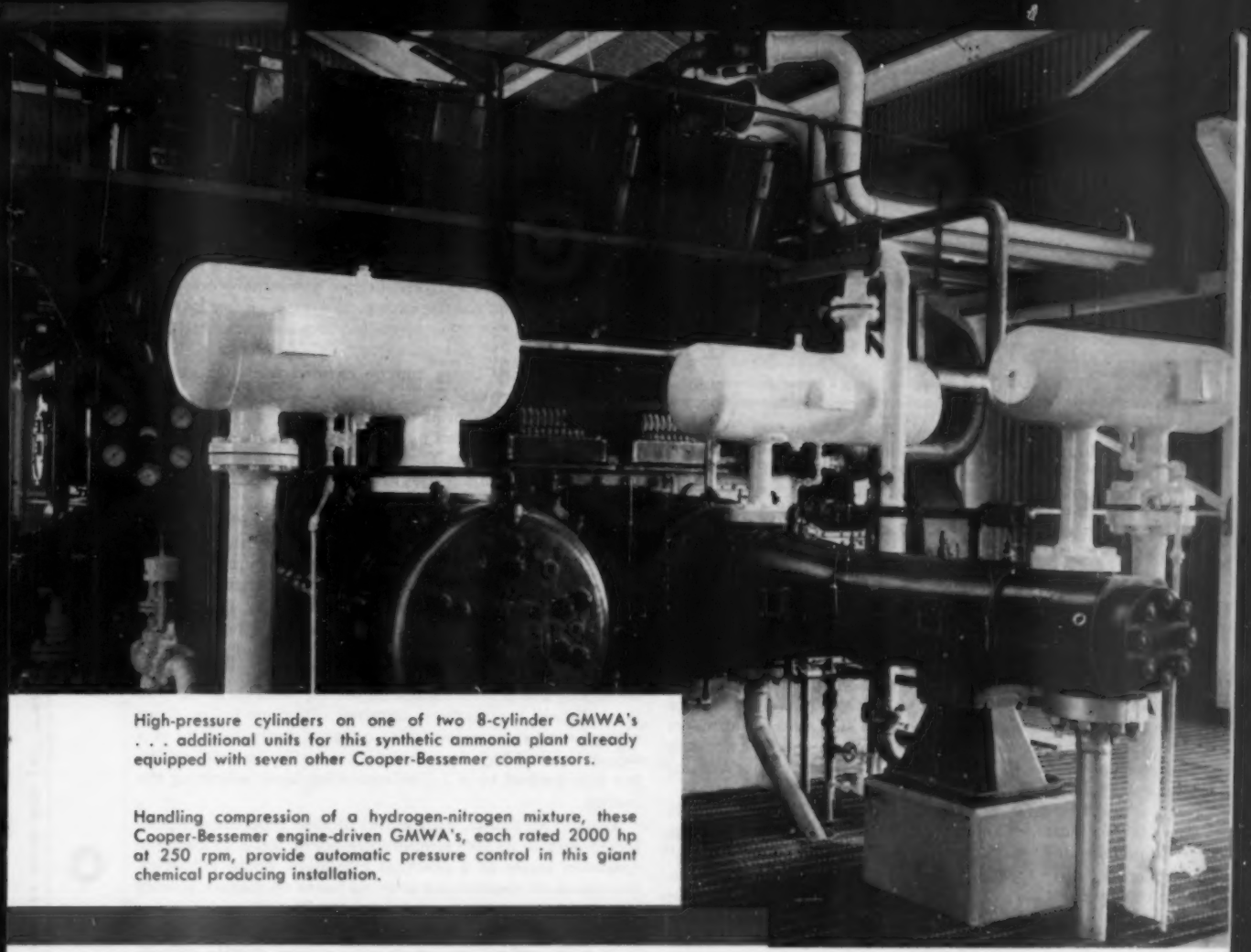

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TABLE 2. Corrosion rates. Penetration, .001 inches/year.

Material	I Carb. Steel to 3% Chr.	II 4-6 Chr.	III 6-8 Chr.	IV 8-10 Chr.	V 18-8 Chr.
Temp. F					
550-600	3.5	1.3	—	—	—
600-650	5.5	2.0	1.2	1.0	—
650-700	8.0	3.0	1.8	1.4	—
700-750	12.0	4.5	2.8	2.0	1.0
750-800	18.0	7.5	4.2	3.0	1.5
800-850	27.0	11.0	6.5	4.8	2.5
850-900	40.0	17.0	10.0	7.5	4.0
900-950	60.0	25.0	14.0	10.0	6.4
950-1000	90.0	40.0	23.0	17.5	10.9
Price ratios, approx.					
C.S.	1.0				
C-Mo.	1.8				
1¼ Chr.	2.0				
2¼ Chr.	2.8	3.45	3.60	4.60	11.00

rates as shown in Table 2 and with tube metal temperatures up to 875 F at the outlet, in order to obtain a useful life of the tubes of 10 years with total corrosion below ⅛ in., the portion of the tube bank with metal temperatures of 700-800 F will have to be made of 5 chrome alloy and the remainder of the coil of 9 chrome. Increased costs of the alloy portions of tube bank will not be the same for each heater, so that the differential on the fixed charges due to the cost of the alloys may make heater B more profitable than heater C, or make heaters D and E feasible with a fuel cost lower than 35 cents per million Btu.

Corrosion rates shown in Table 2 are specific for a particular charge from a high-sulfur California crude as processed in a certain refinery. The rates may not apply to a charge from a different crude with the same total sulfur content but with different sulfur components, particularly if the charge is processed with a different type of heating curve and phase relationship through the coil.

When the rates of corrosion through the coil can be estimated only as to the order of magnitude and a change from one alloy to the next best in a section of the coil means a large increase in cost of the section, as for example, a change from carbon steel to 5 chrome or from 9 chrome to 18-8, the section is sometimes purposely "underalloyed" to keep down the original cost. The fixed charges and substitutions, as required by the actual corrosion rates, are charged to repairs and replacement costs. The opposite approach is to slightly over-alloy the section and accept higher fixed charges to make sure that no replacements and extra shut-downs are required during the useful life of the heater. Under certain types of tax structure, under-alloying may give a higher net profit than over-alloying even when the cost of the replacements and the loss of profits during the extra down time is considerably higher than the extra fixed charges of the better alloys.

Fig. 1 shows the basic types of process heaters that account for the major portion of the heaters built in the last ten years.

Structurally, a process heater has four major components: 1. The setting, 2. the coil, 3. the fuel burning equipment, 4. auxiliaries.

The Setting

The setting consists of the structural skeleton, the casing, the refractory lining and the auxiliary refractories inside the heater such as target walls, bridge walls, re-radiating cones, etc. In this article, the header boxes, end tube sheets and intermediate tube supports are considered a part of the setting because they are structurally tied in with the setting.

Structural skeleton of the heater is designed with a much higher factor of safety than used in ordinary structures to take care of thermal stresses produced when the heater is brought on or taken off stream. In the more conservative designs, the structural skeleton is further reinforced to withstand, at least for short periods, the effects of an outside fire in the vicinity of the heater or of flames through the openings in the heater caused by a ruptured tube. Some refineries specify that the main structural members of the heater are fire-proofed a certain distance above grade as additional protection.

The casing is usually made of 10-12-gage sheet steel bolted or welded to the structural skeleton or to intermediate lightweight members between the structural members. Some heaters have transite or similar boards instead of sheet steel for the casing, and occasionally, with some types of suspended fire-brick construction, a weatherproof coating is susbstituted for the casing. The steel casing is more expensive than the other types but requires practically no maintenance.

The refractory lining can be divided into two groups according to service:

1. Shielded refractories that are located behind the tube banks and are protected by the banks from the major portion of direct radiation. These refractories are generally out of the path of the main stream of gases so that they seldom exceed 1800 F on the exposed face.

2. Bare refractories, exposed to full direct radiation. The bare refractories are also out of contact with the main stream gases, except where some refractories are purposely washed by the gases to increase their temperature and re-radiating effect, as the center wall in heater E, the side walls in heater G and the cone in heaters J and K.

The shielded portion of the lining is usually made of high-temperature insulating brick shapes 4-5 in. thick backed by 2 or 3 in. of insulating blocks, blankets or cement. Some linings are made of castables using one 6-9-in. layer of high-temperature insulating material throughout or of a 4-5-in. layer of high-temperature insulating material on the hot side backed by a 2-3-in. insulating layer adjoining the casing.

Usually all linings, irrespective of their type, are designed for an outside surface temperature below 200 F to keep the radiation losses at a practical minimum. Some refineries, for reason of comfort and to avoid burns on contact, specify an outside temperature not over 150 F.

There are two general types of construction of linings built with prefired insulating brick shapes, gravity, or non-suspended construction, where the shapes are laid in courses as a self-supporting wall, and modified suspended construction where the shapes are held in place vertically by rods or light angles and supported horizontally on shelves tied-in to the casing or the structural members.

For walls over 6 ft high, gravity construction can be used satisfactorily only in circular heaters. The shapes, usually wedge brick for diameters up to 6 ft and circle brick for larger diameters, form a stable structure vertically and horizontally because the shapes are restrained against movement towards the inside by the arch effect of the circle and toward the outside by the back-up installation and the casing. With rectangular heaters, the wall, to be stable, must be of modified suspended construction.

Fig. 2 shows the various types of construction of linings using insulating refractories. Fig. 2A is the gravity or non-suspended construction used in heaters J and K. Fig. 2B and 2C show one type of modified suspended or tied-in brick construction used in the walls of rectangular heaters. Fig. 2B uses 4½-in. insulating brick backed with 2½ in. of insulating block. The insulating brick are supported about every 15 courses on alloy clips attached to supporting angle and are strung on alloy rods between the clips to assure vertical stability. Fig. 2C shows the same type of construction using 9-in. thickness of brick and 1 in. of insulating block. The rods and the horizontal supporting members in this construction are made of plain steel because they are far enough removed from the hot face and are usually at temperatures below 500 F. Types B and C are substantially equivalent in insulating value and almost equal in price because the thinner wall requires alloys and

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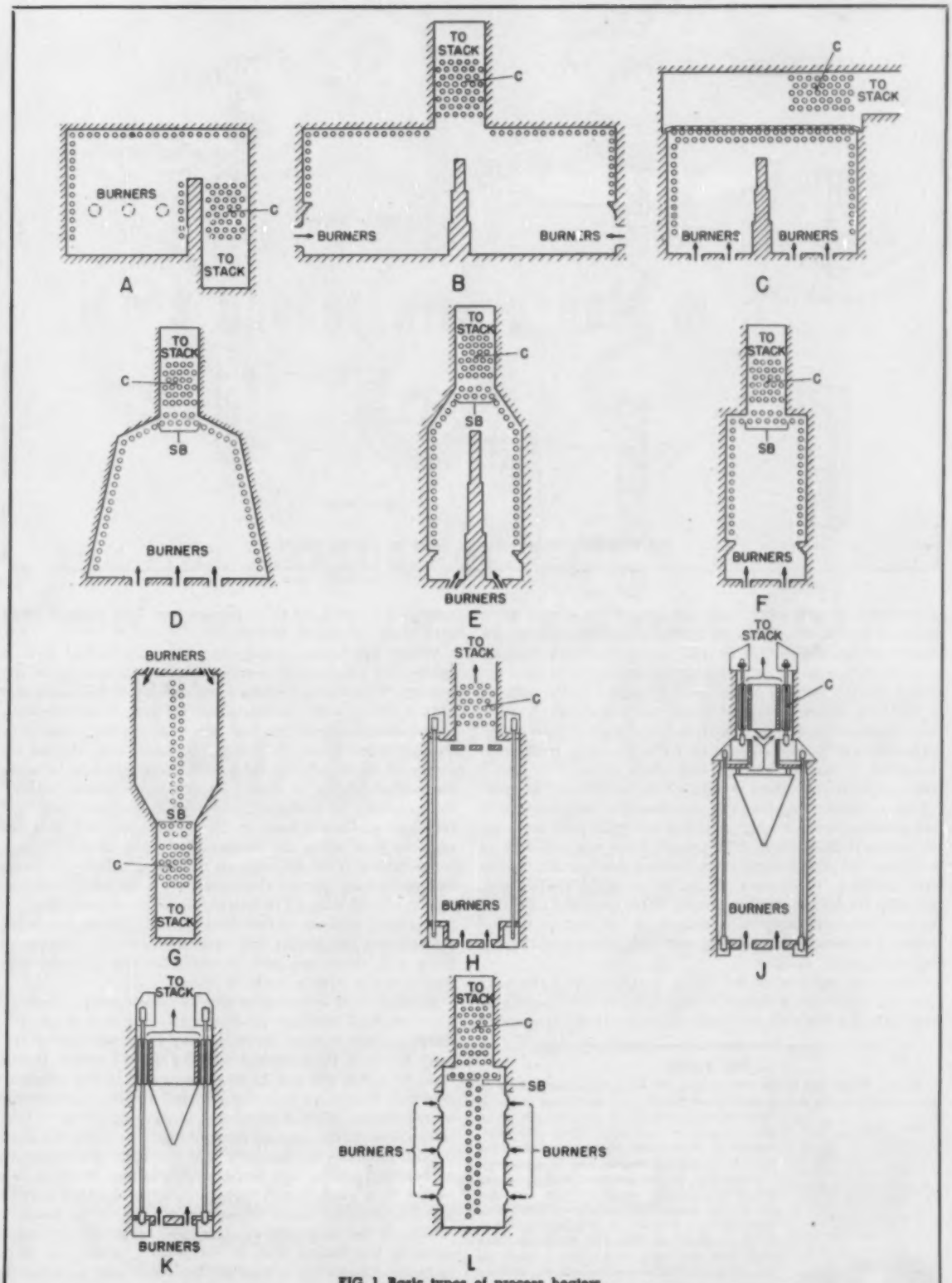

FIG. 1. Basic types of process heaters.

slightly more fabrication for the supporting members than the thicker wall with a more expensive insulating refractory brick. A substantially similar construction with the rods running horizontally is used for the protected portion of flat roofs as shown on Fig. 2D.

Fig. 2E shows another type of semi-suspended wall con-

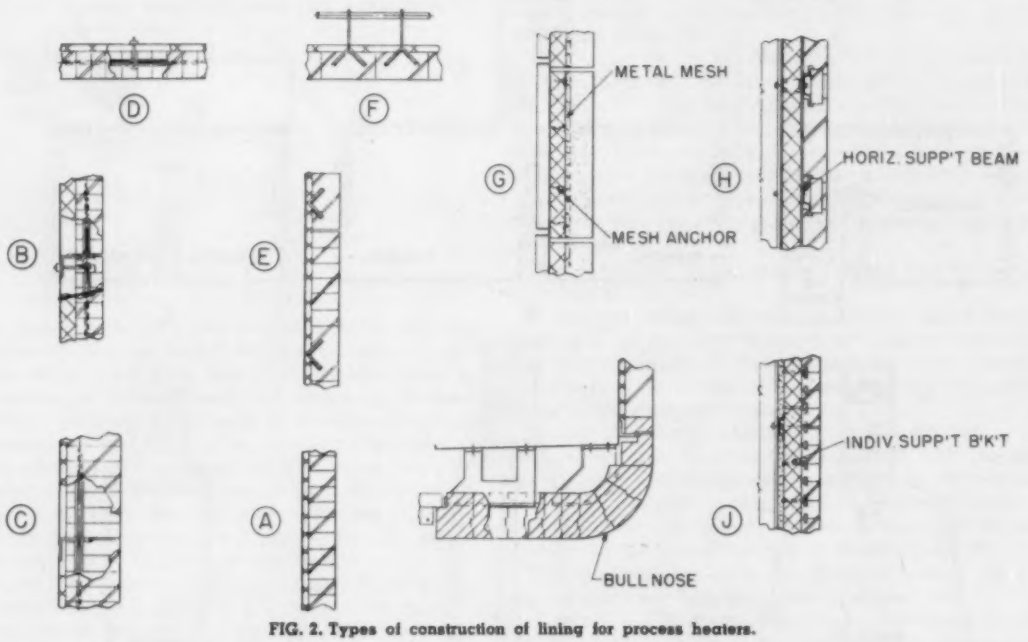

FIG. 2. Types of construction of lining for process heaters.

struction where gravity wall sections of insulating brick made of 8-10 courses with the bricks cemented together are supported on angles that fit into cuts in the brick. Similar construction with all brick supported on angles is used for the protected portion of the roof, as shown in Fig. 2F.

Fig. 2G shows a type of panel-wall construction using two layers of castables originally developed for lining regenerators of catalytic cracking units. Castable panel construction is usually quicker and often cheaper to install than prefired, insulating refractory shape linings. The castables, however, may require considerable maintenance if not installed with utmost care. For example, with cast construction, if the casing of the panels is not supported properly and the panels warp after the castable has set, forcing the panels in place may strain the lining so that it may develop cracks and spall in service. With gunnited construction, if rebound material is reused, it will reduce the coherence between the particles and may also cause the lining to crack or spall.

The bare portions of the lining, particularly of the roof, and the bullnose or knuckle rings around the opening in the wall and the roof are made of conventional suspended construction with fire-brick shapes 5 or 7 in. thick, backed with block or plastic insulation.

Where applicable, insulating refractory linings have a number of advantages over linings with fire-brick on the hot face. With a given hot face and outside surface temperature, a lining with insulating refractories is considerably lighter and has less than half the heat-storage capacity of an equivalent fire-brick lining. The lower heat-storage capacity of the insulating refractory lining permits bringing the heater quickly to steady on-stream conditions without the necessity of first over-firing the heater just before it comes on-stream, to heat up the refractories, and then cutting the fires when the refractories reach an equilibrium temperature. A heater with an insulating refractory lining will cool much quicker than one with a fire-brick lining so that it can be entered in shorter time for inspection or repairs. Also, because of low heat capacity of the insulating refractories, the heater will respond faster to changes of firing and, therefore, will be easier to fire automatically than a heater with a fire-brick lining.

Another type of lining, originally developed for regenerators on fluid catalytic cracking units and now applied to some process tubular heaters, uses fully suspended fire-brick tile 3 in. thick backed with 3-4 in. of block or plastic insulation. Fig. 2H and 2J show two types of this construction that is used for both the shielded and the bare portion of the lining. With a relatively large proportion of bare refractories in the linings, these linings may have the same overall heat-storage capacity and the same characteristic of heating, cooling and response to changes in firing as a heater with insulating refractories in the shielded portion and 5 or 7 in. fire-brock in the bare portion of the lining.

Where the bare refractories are purposely impinged upon by the flames, such as the portion of the side walls in heater G and the bottom of the center wall in heater E, super-refractories are used normally. In heaters J and K, the cone, which acts as bare reradiating refractory washed by the main stream of gases, is made of cast or wrought 25-12 or 25-20 alloys.

Part II will appear in an early issue.

The Author

Born in Russia late in the 19th century, Dr. Mekler attended college in three countries, his native land, Great Britain and the United States of America. In Scotland, he received the bachelor's degree in metallurgy, 1915; at the University of California, he was awarded the Bachelor of Science degree, also in metallurgy.

Since then, he has practiced metallurgy and heater design as a consultant, and with Universal Oil Products Company, 1919-21, and then again in 1927-45. He has been active as as a consultant at Palo Alto, California, and New York City from 1945 to the present. He has more than 80 patents on heaters, burners, catalytic processes, instrumentation, waste heat utilization, and other fields. He has published some 40 articles and publications in these fields.

At present, he is or recently was consultant to Armour Research Institute, Institute of Gas Technology, and Stanford Research Institute, as well as other clients.

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Analytical Methods

Determination of CO^2 in Steam and Condensate

Maxey Brooke
Technical Correspondent

CARBON dioxide is determined in natural water by titrating with standard alkali to the phenolphthalein end point. The carbon dioxide content of steam and gas condensate is frequently greater than the solubility of the gas at room temperature and pressure. When this condition exists, most of the carbon dioxide will flash when the sample is taken. The following method was developed to eliminate this flashing.

Reagents required:

A. 0.1 N sulfuric acid.

B. Approximately 0.1 N sodium hydroxide solution prepared with freshly boiled water.

C. 1 per cent solution of phenolphthalein in methanol.

D. Mixed indicator prepared by dissolving 0.2 grams methyl red and one gram bromocresol green in 500 ml isopropanol.

The success of this test depends upon the care taken in sampling. It is necessary to condense and cool the steam and steam condensate. If there are several sampling points, it is convenient to have a portable condenser. A 5-ft copper coil in a 3-gal bucket can be used. The condenser is filled with crushed ice and water. Blow the sample line down thoroughly before taking the sample.

The sample is collected in a 1000 ml volumetric flask containing exactly 100 ml of the sodium hydroxide solution. The end of the condenser is inserted *below* the solution and the sample is collected slowly until the volumetric flask is filled to the mark. If tightly stoppered, the sample can be retained for some hours before making the analysis.

EXCLUSIVE

FIG. 1. Drawing of condenser for sampling steam, designed to prevent flashing of contained carbon dioxide when collecting sample.

To a 100 ml aliquot of the sodium hydroxide-condensate mixture add five drops of phenolphthalein indicator and titrate with 0.1 N sulfuric acid to a colorless end point. Record this titration as P. Add five drops of mixed indicator and without zeroing the burette, titrate to a red end point. Record the total titration as M.

In a like manner, determine the P and M values by titrating 10 ml of the original sodium hydroxide solution. If the M reading is not the same for both blank and aliquot, the determination is in error and should be discarded.

The calculations are made as follows:

For the blank:

$$2(M - P) \times 220 = B \text{ (ppm } CO_2\text{)}$$

For the aliquot:

$$2(M - P) \times 22 = A \text{ (ppm } CO_2\text{)}$$

Then:

$$0.9X = A - (0.1 \times B)$$

Where:

X = ppm CO_2 in the condensate.

Example:

Blank: P 6.9 M 7.5
Aliquot: P 6.4 M 7.5
Blank: $2(7.5 - 6.9) \times 220 =$ 264 ppm CO_2 . . (B)

Sample: $2(7.5 - 6.4) \times 22 =$ 48.4 ppm CO_2 . . (A)

Then: $0.9X = 48.4 - (0.1 \times 264)$

$X = 24.4$ ppm CO_2 in sample

An example of the usefulness of this method is a carbon dioxide balance around a boiler. The following analyses are known.

	Boiler Feed	Boiler Blowdown
ppm chlorides	50	710
ppm carbonates as CO_2	220	61.6

Per cent blowdown $\frac{50 \times 100}{710} = 7.0\%$

Basis: 1,000,000 lb boiler feedwater
Pounds CO_2 in the feed water..... 22.0
Pounds CO_2 in blowdown..... $0.07 \times 61.6 = 4.3$
Pounds CO_2 in steam..... $22.0 - 4.3 = 17.7$
Ppm CO_2 in steam..... $17.7 \div 0.93 = 19.1$

The actual carbon dioxide in the steam as determined by this method was found to be 19.0 ppm, while the content as determined by the conventional method was 5.0 ppm. ★ ★ ★

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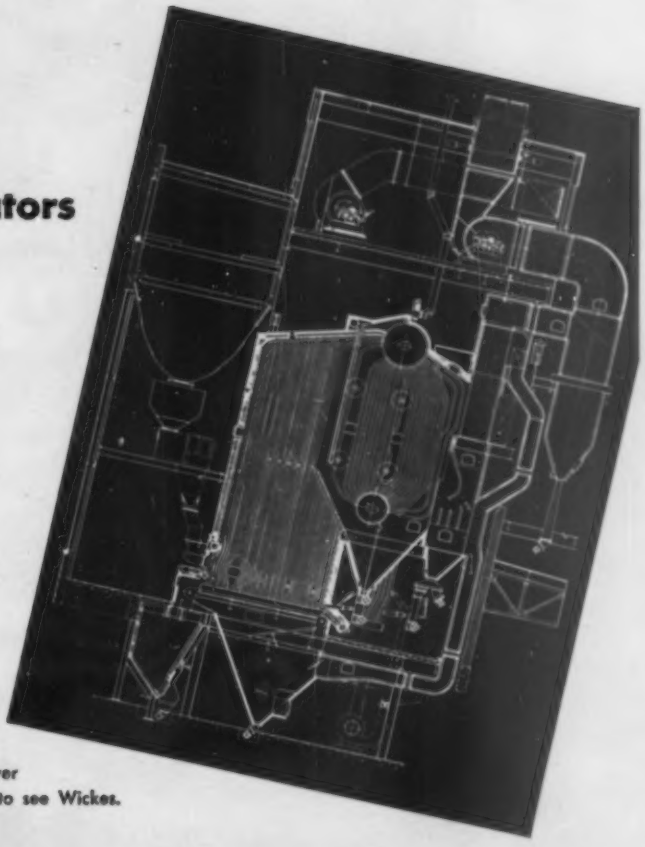

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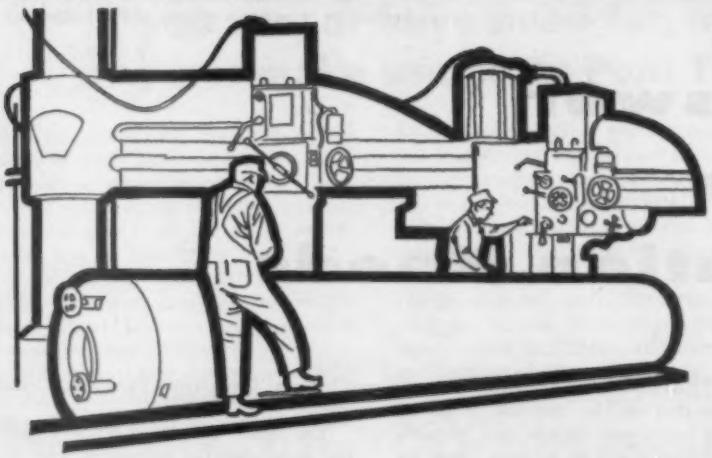

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Whiting, Indiana, refinery fire, where radio helped to lessen the effects of the holocaust.

P 769.2

Radio's Answer to Refinery Communication Needs

Joseph A. White
Motorola Communications & Electronics, Inc.

From 1948 to 1955 refinery radio mobile transmitters increased 48-fold

EXCLUSIVE

EXPERIENCES in recent months indicate that the day may not be far off when a two-way mobile and portable radio system will be a "must" item for every modern refinery and petrochemical plant.

Acceptance of radio has been spurred by several factors recently — such as the vital role played by radio communication during the Standard Oil refinery fire at Whiting, Indiana; the excellent results obtained from the new uncongested 450-mc Petroleum Radio Service band in use at the General Petroleum Corporation refinery in the Pacific Northwest, and operational success of radio dispatching at Dow Chemical Company's Freeport, Texas, plants.

The steady growth of refinery radio has paralleled the petroleum and gas industry's open-arm adoption of wireless communication since the end of World War II. In 1948, for example, the Federal Communications Commission listed only 412 petroleum radio licensees, with fewer than 500 mobile sets authorized. By comparison, 1955 saw the number of radios in use by this industry rise to 4772 fixed stations and over 24,000 mobile transmitters.

Of course, not all of these radios are in refineries. Great quantities of radio communication equipment have been

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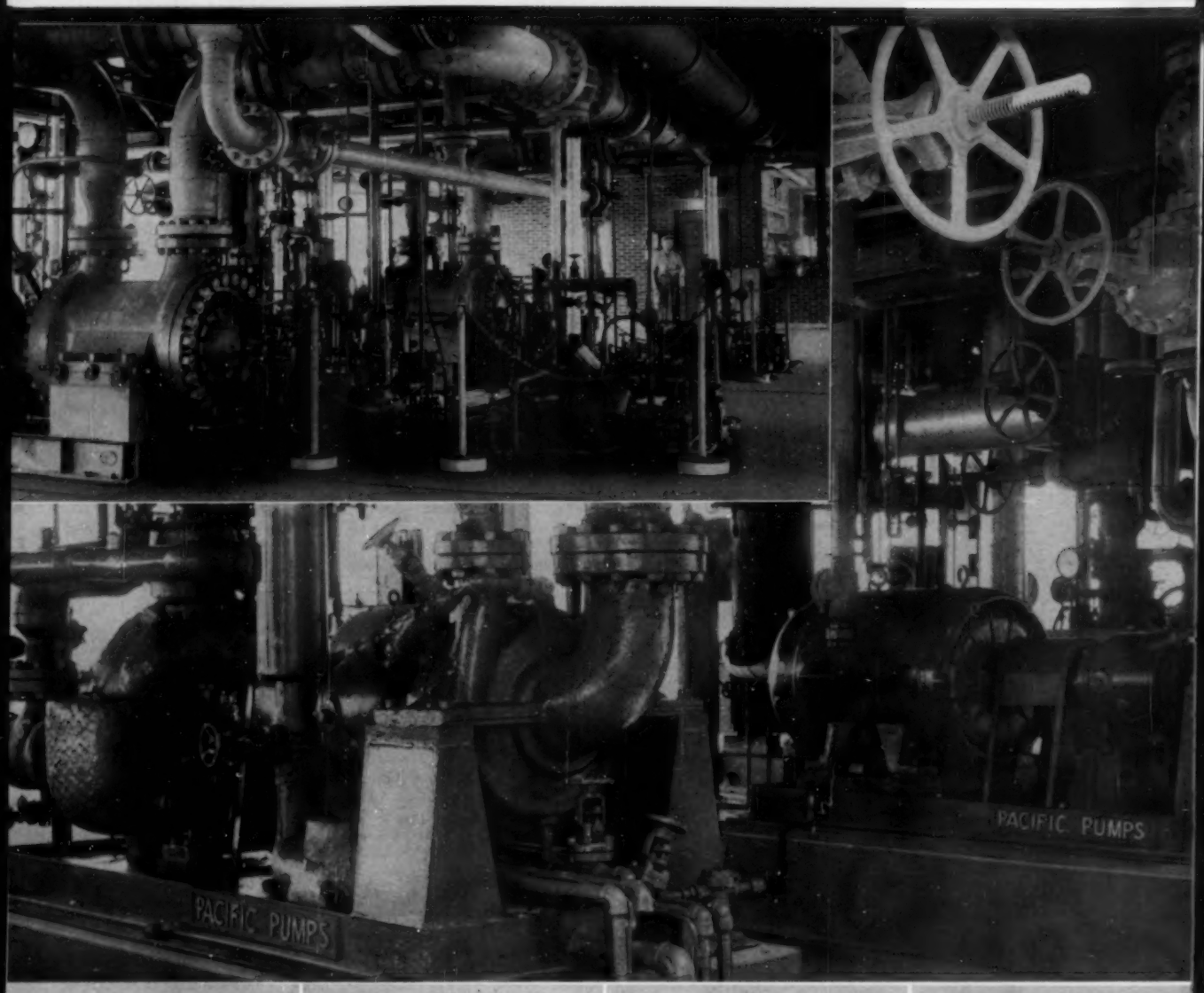

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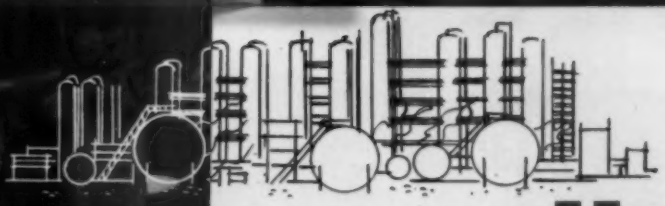

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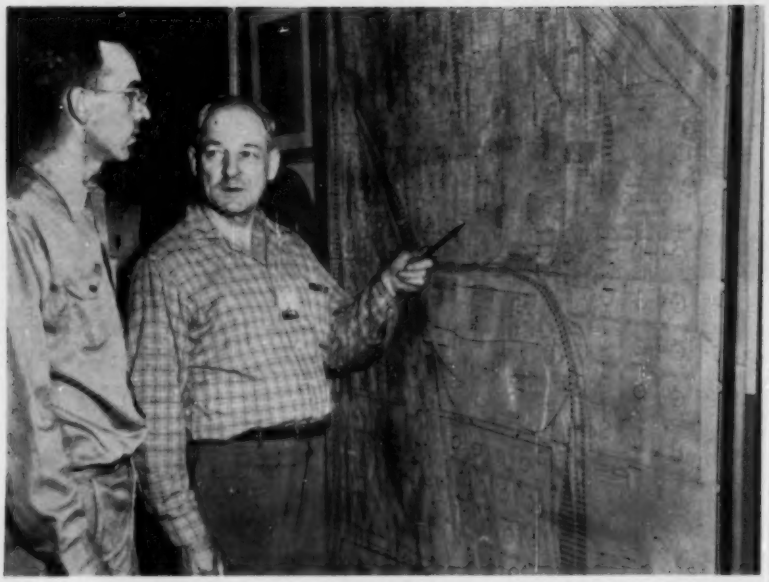

With aid of refinery map, R. R. Wilson, Standard Oil of Indiana's asphalt division superintendent, pinpoints location of new blaze. Firefighting was radio-directed after flames destroyed plant phone system at Whiting.

absorbed by exploration and new production in West and North Texas, Wyoming and recently in southern Louisiana. It is a fact, however, that where oil is found, refineries follow. And modern refinery planning regards mobile radio facilities as necessary tools for efficient transportation, dispatching and safety services.

Mobile/portable radio experienced one of its finest hours last year in the August 27 explosion and fire at Standard Oil of Indiana's Whiting refinery. Fortunately, the devastation was limited to a relatively small area because the refinery management was ready with emergency preparations mapped well in advance.

The first blast occurred early in the morning at the 26-story fluid hydroformer — the first of its kind in the world — as the new reforming unit was being returned to operation after a shut-down. Flying metal fragments punctured near-by storage tanks, which ignited and loosed flaming oil.

Paul Matt, truck dispatcher handles traffic over 25-w base station during fire.

Immediately after the blast, the disaster alarm was sounded and a fire-fighting pattern began to take shape. Foam was applied to burning tanks and oil pool, while hundreds of water hoses played on adjacent tanks that were near the bursting point because of intense heat. Scores of trucks rushed in sand for construction of dikes. In all areas, fire fighting was directed from an emergency headquarters set up in the plant fire marshal's office, using Standard's 250-w industrial radio station as the means of conveying orders to the trucks, and plant telephones for fixed communication with other offices and gates.

Within a few hours, a new crisis arose as flames reached the main telephone terminal block and knocked out the entire plant phone system, including outside lines. Loss of wire lines took the base radio station off the air also.

However, this Sunday punch at the communications system did not in any way slow the radio operation. Immediately, trucks equipped with two-way radio sets were moved up to serve as temporary base stations — in most cases were parked outside the window and the microphones extended inside to the men in charge. These emergency stations were pressed into service first at the fire marshal's office, then later at the refinery motor pool office and at the main plant protection headquarters at the east gate.

Throughout the refinery, other radio-equipped vehicles were spotted at strategic points along plant boundary roads, at plant gates and at intersections near the disaster scene. Through these mobile control points, directions were quickly and accurately relayed to the sand truck drivers and to fire-fighting personnel. Every key traffic area had a mobile radio unit, with runners, which relayed orders from the fire marshal's office.

A rush call to the Motorola radio factory in Chicago, Illinois, brought 3 small AC-operated table-top utility base stations within a few hours (this was on a Sunday), and so the temporary mobile-base units were freed for field use.

Before the fire, Standard's radio system had consisted of 36 mobile units in various plant vehicles, 2 portable sets, and the ¼-kw base station remotely controlled from any of five dispatching points. After the smoke cleared, the system had grown to include the 3 table-top AC units mentioned above, plus 20 Motorola portable pack sets and 5 handie-talkie radiophones, for a total of 63 mobile and portable sets and four base stations.

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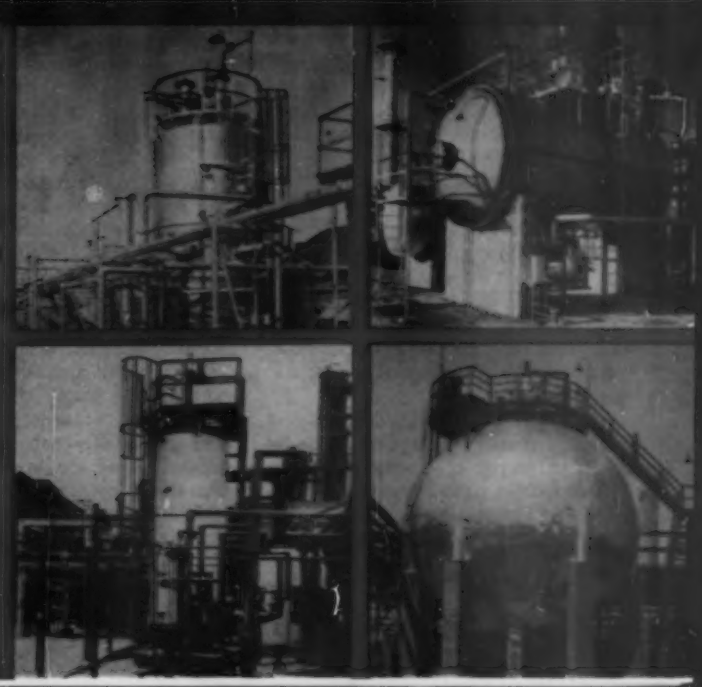

Mobile radio unit near fire at Whiting handles aid units. It also served as temporary base station when main station was destroyed.

came during the first afternoon at Whiting when a flare-up occurred at a naphtha storage tank, sending orange flames hundreds of feet in the air. The intense heat touched off a fire in the vent of the nearest tank of the 30-tank field across the highway from the main refinery.

A driver in a Standard Oil radio truck, seeing the fire start in the new area, broke into the radio traffic with a high-priority request for all available fire-fighting equipment to be sent to the scene. His call, coming just a few seconds after the latest blaze broke out across the highway, resulted in the new fire being caught early and extinguished quickly.

Needless to say, the Whiting refinery fire convinced Standard's management of the value of: (1) Flexible mobile and portable radio communications and (2) a communication system independent of plant telephones and AC power lines.

The important role filled by radio at Whiting should be studied fully by every other refinery safety committee where mobile radio systems are available. The radios can play a similar part in any industrial disaster plan.

Such a plan is mapped out and kept in readiness at the new General Petroleum Refinery near Ferndale, Washington, where every man is assigned and rehearsed in his disaster duties, whether he is a nozzle man, medical aid or general utility man.

At Ferndale in case of disaster, all radio trucks would go on a listening-standby status in order to keep the air channel clear for priority traffic. Radio vehicles would also be deployed around the fire so as to give communication coverage from every direction.

In everyday routine, General Petroleum's Ferndale radio ties closely into the refinery safety program. Before a welder can ignite his torch, for example, the immediate area must be tested for presence of gas. Here the mobile radios save many manhours each week. The welder telephones to the radio dispatcher and asks for a gas check. By radio, the request is relayed to the safety truck, whose driver is directed to the scene immediately to give the go-ahead signal. If some slower method were employed for locating the safety inspector, the welding crew would be held up longer at a resulting waste of manpower.

The General Petroleum Corporation refinery embodies the last word in automatic controls throughout. Still, even the most advanced automation requires expert operation, maintenance and safety methods, and there also are the ever-present construction projects. To keep close contact with key personnel throughout the 900-acre refinery, 20 cars and trucks are fitted with Motorola two-way, FM radios. The base station is situated atop the thermofor catalytic cracker and is remotely controlled from dispatch points at the gatehouse and in the maintenance office.

Normally, the radio system is used primarily for relaying calls to the materials-handling truck drivers, the maintenance and construction supervisors, and safety crews. In addition, each radio driver acts as a spotter as he makes his way around the refinery. Thus, a locator call may go out on the air for some person not readily available in a radio vehicle, and he will be given the radio message by the first radio driver to come upon him.

During the night shift, the Ferndale radio takes on another function—communication between the nightwatchmen and the plan protection guards at the gatehouse.

Because of the refinery's location within 10 miles of the Canadian border, there was some likelihood that a radio system operating in the 150-mc petroleum band (in use at the company's Torrance, California, refinery) might cause interference to Canadian radio users. To avoid this possibility, General Petroleum elected instead to use the new 450-mc petroleum frequencies, and in so doing became the first petroleum company licensed by FCC to operate in the UHF band.

Coverage of the 450-mc radio system exceeds 12 to 15 miles in all directions, which is more than adequate to reach all refinery vehicles, yet is not likely to cause interference to other radio users.

Radio coverage requirements vary widely among refineries and similar petrochemical installations. For example, the Dow Chemical Company has found so many tasks which radio can do well that three separate radio systems are needed at its Freeport, Texas, plants — one for the motor transportation division, another for the extensive pipe line network used in gas and water department operations, and still a third system for use by the fire, plant protection and other departments. Eventually, about 15 base and 100 mobile stations will be used in the three systems.

In miles, Dow's VHF radio-cover-

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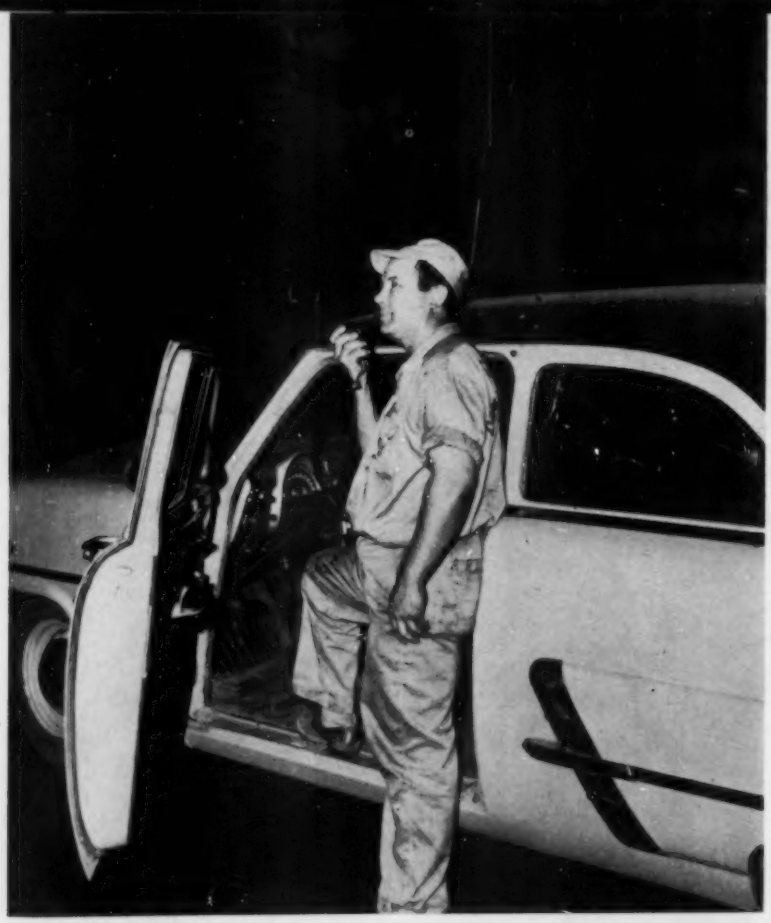


Technician Lowell Lindquist, who kept Whiting's radio system operating from his mobile, two-way unit-equipped car.

age area far exceeds the usual refinery or industrial plant requirements. The pipe lines that bring fuel and raw materials into the Freeport plants extend many miles away, and operational control is needed far out along these lines. To lengthen the VHF radio coverage, a microwave relay system has been added between Freeport and automatic unattended base stations located 37 and 44 miles away at Bay City and Thompsons.

To put the VHF-and-microwave system into operation, any Dow mobile or fixed-station operator simply presses a control button at his transmitter, sending out a radio signal that turns on the remote station and alerts it to relay the message. By use of this system, the mobiles automatically select the closest VHF base station and effectively extend the mobile radio coverage up to 90 miles from Freeport.

By a tie-in with the plant radio station and the Dow telephone switchboard, conversations can be set up between mobile units in the field and any office in the plants. Dow's pipe line radio network gives blanket communication coverage throughout the gas and water operational area, which now extends approximately 50 miles in each direction along the Gulf Coast and inland nearly the same distance from Freeport. Sixty-watt mobile transmitters are standard in the pipe line network to achieve the maximum reliable talk-back range of field cars and trucks.

Dow's first Freeport radio system in use was the emergency network. Recently, this has been supplemented by the motor transportation dispatching system, which includes selective calling of individual mobile stations—one of the most promising advances in industrial radio development.

Selective calling works this way: In conventional two-way mobile radio systems, every receiver tuned to the transmitting station frequency reproduces each message spoken over the air, regardless of whom the message is addressed to. The result is that each driver must monitor every transmission (even though the message may not pertain to him at all) so as not to miss the one call in 10 or 20 directed to him.

With Motorola selective calling, only the one receiver where the dispatcher wants his voice to be heard is "on" during his transmission; all other receivers in the system remain muted, thus relieving drivers of the monotonous duty of monitoring countless irrelevant messages.

This method of selecting individual or groups of receivers is accomplished by means of audio tones selected by the dispatcher at the press of a button. The tones go out on the radio carrier and pass through all receivers on the air channel, but only the receiver pre-set to respond to the chosen audio tones is switched on. By making individual receivers responsive to different tone combinations, the dispatcher can pinpoint the one mobile driver he wishes to hear his voice. It is simply a matter of transmitting the correct audio tones to trigger "on" the desired receiver.

If the driver happens to be away from the radio at the time his truck is called, a warning light comes on and stays lit. When the man returns, the signal light indicates that his vehicle was called in his absence, whereupon he radios in and gets his message.

In addition to privacy, the big advantage of selective calling is in reduction of driver fatigue. Under this system, drivers don't have to keep their ears glued to the set so as not to miss the one call in many that may be for them.

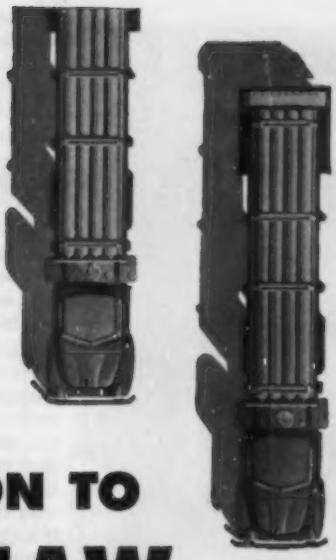
At Dow, the motor dispatch offices at Plant A and Plant B are both tied in by wire line to the base station, with duplicate signaling facilities at each office. This adds flexibility by permitting operation by either dispatcher.

All the Dow radio systems are planned to accommodate future expansion without obsoleting present equipment — a long-range philosophy that anticipates the needs of 10 years in advance. This is sound reasoning because past experience has shown constantly widening use of mobile radio equipment.

Based on the past decade, refinery and industrial radio usage can be expected to grow even more rapidly as more managements become aware of the value of instantaneous mobile communication. And as usage multiplies, more equipment improvements can be expected from the highly competitive electronics manufacturing industry.

Some equipment advances already are seen in the offing. Among the most significant are:

1. Wide use of transistors and other semi-conductor devices to replace today's vacuum tubes.
2. Greater application of selective-signaling methods to filter out unwanted and interfering signals as radio channels become more congested.
3. Much improved portable radiophones, giving greater output with smaller size and longer battery life.



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- Fluoboric Acid
- Fluorine Cells
- Fluorinating Agents
- Frosting Mixtures
- Hydrofluoric Acid Anhydrous
- Hydrofluoric Acid Aqueous
- Hydrofluosilicic Acid
- Lead Fluoborate
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Transistors hold most promise to the petroleum industry as the means of increasing equipment reliability, decreasing power drain and shrinking the size of future radio sets.

In the estimate of Daniel E. Noble, vice president of the communications and electronics division of Motorola, Inc., transistors will not seriously challenge the dominance of the vacuum tube in most vehicular applications until sometimes in 1958 or '59, and then only in those applications where size, weight, power drain and reliability are particularly important.

And optimism over the approach of transistors must be tempered with the realization that transistorized radios will not provide better communication than vacuum tube models. You will not be able to talk any farther or clearer with the transistor sets. Consequently, it is short-sightedness to "wait out" the coming of transistorized equipment if by waiting you deprive yourself of the benefits of radio communication in the interim. Also, the coming of transistorized equipment will not obsolete present radio systems, because the new sets undoubtedly will be built to work interchangeably with today's vacuum tube sets.

Typical of the continually improving two-way radio equipment being offered to the petroleum industry are the new Motorola handie-talkie portable radiophones recently announced.

Marking this manufacturer's first use of transistors in two-way equipment, the portables are more powerful in RF and audio output and easily adaptable to operation from 6 or 12-v automobile ignition systems as a means of saving (and recharging) the internal batteries.

No longer are these portables rated in milliwatts of power. The new models have outputs ranging from 1 to 8 RF, extending the coverage far beyond that of other portable two-way radiophones. Other features are lighter weight for easy portability; use of nickel-cadmium batteries in a transistorized power supply, which completely eliminates vibrators, are lifetime rechargeable without limit to the number of recharge cycles, and are not harmed by long storage periods; external adjustable volume and squelch controls and automatic cut-off switch; plated circuitry and swingout subassembly construction for ease of servicing.

Final test of two-way radio's position with refiners is to ask present licensees their opinion of the wireless tool. The three users chronicled in this story have given radio the best endorsement possible—that is, they keep buying more sets. They give a definite impression that refinery radio is here to stay. * * *

PETROLEUM CHEMICALS DIVISION
NEWS

March ★ One of a Series of Interest to the Petroleum Industry ★ 1956

Question Box

1. ARE YOU having trouble keeping costs down as octane ratings go up?
   The new Du Pont service described at right can help you with this problem.
2. DO FOULED heat exchangers plague you with costly downtime and spoiled product?
   Du Pont FOA-2 may help solve this problem.
3. IS THERE A DANGER of additive extraction when fuel oils pass through dehydrators?
   The next page has an article on this subject.
4. WHO can help you get the highest octane at the lowest refining cost?
   See next page.

FOA-2 reduces heat exchanger fouling—helps keep process unit on stream longer

Fouled heat exchangers cost time and money and premature process unit shutdowns.

Du Pont Fuel Oil Additive No. 2 (FOA-2) promises relief from this frequent and troublesome problem.

A little does a lot

Fouling due to unstable stocks such as coker distillates can be minimized by adding FOA-2 in concentrations of as little as 20 to 30 lbs. per 1,000 barrels. It should be added at the beginning of the processing run.

In cases where the heat exchanger fouling is severe enough to cause shutdowns as often as every few days, this treatment will generally extend, to as much as a month or two, the period between shutdowns. And during this extended operating time, FOA-2, as a result, will help to reduce the loss in heat transfer coefficient.

Useful in pipelines, too

Another effective application for FOA-2 is for cleaning pipelines. In concentrations of 50 lbs./1,000 barrels, in No. 2 distillate, it does an excellent job of keeping the contamination in suspension and removing it in advance of the new product.

Why not try it? Its rapid, thorough cleaning will mean lines that are free of contamination and ready for clean product service immediately.

Other uses

Du Pont Fuel Oil Additive No. 2 was originally developed as a stabilizer and dispersant for home heating oils. As such, it does a highly efficient job of preventing and dispersing sludge formations that cause screen and filter clogging.

In addition – being a nonmetallic *ashless* additive – it does not leave a metallic ash deposit which can foul the operation of the electrical system. Thus, it helps to prevent ignition failures that cause customer dissatisfaction and wasteful service calls.

In diesel fuels, the excellent dispersant action of FOA-2 improves filterability. In this way, it helps to eliminate most injector-sticking and filter-plugging problems.

THIS DU PONT TECHNICAL SERVICE MEANS...

More octane numbers per dollar

Octane requirements are increasing so fast that many refiners are facing the choice of either a squeeze on their profits or an advance in their gasoline price. This predicament is brought about by the pyramiding costs of each octane number increase in the 90 to 100 range. In this connection, there are times when a refinery technologist experienced in this specialized field may be of considerable help in the control of costs.

Jack S. Bellah, a Du Pont refinery technologist, is shown here discussing a more economical method of obtaining octane numbers.

The Du Pont Petroleum Chemicals Division is glad to offer you the services of such specialists. The value of their services has been proven in a number of refineries during the past year.

Based on market requirements

Unfortunately, most refiners are forced to do a certain amount of uneconomical processing in order to balance their particular market requirements. But this does not mean that substantial savings in processing cannot be realized – by carefully analyzing and adjusting *all* the factors influencing octane costs.

These factors include the particular gasoline blend, the octane level under consideration, and OVER

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PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED *Octane Economy*

the method of achieving this desired level. These factors, and their relation to each other, will vary with each individual refining operation. Also affecting the octane cost are the spread in value between intermediate fuels immediately adjacent to the gasoline fraction, and the flexibility of the market between these fuels and gasolines.

Tailored to your operations

For these reasons, the Du Pont *octane economy service* also takes into consideration all the market factors which influence your refining operations. Then a thorough study of the actual processing operations is made to determine the most economical course for reaching your desired octane requirements.

How it's done

Assuming that catalytic reforming is today the principal processing variable in gasoline quality control, then the method of operating the reformer determines to a large extent the cost of achieving a desired octane level.

For maximum economy

At all octane levels, the most economical cost results when the optimum combination of catalytic reforming operations and tetraethyl lead dosages is used. In some instances the maximum usage of TEL, 3.0 cc per gallon might be more economical than increasing the severity of the reforming operation. But this is by no means always true. Generally a combination of moderately severe reforming conditions, commensurate with the octane requirements of the existing market situation, and intermediate TEL dosages result in the lowest possible costs.

Valuable aid

By determining the most economical processing steps and reforming severity, in relation to your own individual stocks and market requirements, the Du Pont *octane economy service* can provide a most valuable aid to your own process engineering.

If you would like more information about this service and how it can help you maintain your profit margins, just drop us a line.

HEADS DU PONT OCTANE ECONOMY SERVICE

Jack S. Bellah joined the Petroleum Chemicals Division as Refinery Technologist in 1953. A graduate of the University of Tennessee with a B.S. degree in chemical engineering, he completed a year of study under a T.V.A. chemical engineering scholarship.

For six years, he was employed by the Socony-Vacuum Oil Company. His activities ranged from routine control testing through heavy oils blending, conservation engineering, operations control and equipment testing, unit yields and economic studies, process engineering and product development.

He then joined Mathieson Alkali where he was engaged in chemical engineering development work.

In 1946, he became a process-project engineer at Stanolind Oil and Gas Company in Tulsa. After working on two of the large joint venture gasoline plant projects in West Texas, he joined the Refinery Engineering Company in Tulsa in 1950. There he coordinated all the company's process activities and economic studies.

Do dehydrators remove Du Pont FOA-2 from distillate fuels?

Laboratory and field tests prove the absorption rate is *less than 1%*. And the negligible amount absorbed does not interfere with the water removal efficiency of the bauxite dehydrators.

For example

In a field test, 74,000 barrels of a No. 2 distillate fuel oil were treated with 18.8 pounds of Du Pont Fuel Oil Additive No. 2 per 1,000 barrels. This stabilizer and dispersant was injected into the circulating line of the storage tank while the fuel was being recirculated. The storage tank contained 8 inches of water. Since the fuel was destined for shipment through a pipeline, a dry fuel was desired.

The treated fuel was pumped from the storage tank through two 100-barrel capacity bauxite dryers operating in parallel, then into the pipeline. Each dryer contained sixteen tons of bauxite.

The test fuel was sampled before and after the dryers . . . and at regular intervals throughout the 31-hour shipment.

Results

The fuel was bright and dry when it left the dehydrators. The FOA-2 content of fuel entering and leaving the dryers was equal. It remained uniform throughout shipment.

When the fuel was checked in at destination, no loss in stability was noted and in this respect the fuel proved to be superior to the base fuel without additive.

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DESULFURIZING BY HYDROFINING

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D. A. Sutherland
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and F. W. Wheatley
B. Sc. (Hons) A. F. Inst. Pet.
Australasian Petroleum Refinery, Ltd.

DURING the late 1940's considerable research was carried out on the desulfurization of Middle East feedstocks in the gas oil range, at the research station of The British Petroleum Company Ltd., Sunbury-on-Thames, England. A highly active desulfurization catalyst of the cobalt oxide molybdenum oxide on alumina type was developed capable of desulfurizing Middle East gas oils to a residual sulfur content of < 0.1 per cent weight under medium temperature and pressure conditions. Lack of an economic source of make-up hydrogen prevented commercial application of the process at this time, and further research tended towards the Autofining process, which generates its own hydrogen by dehydrogenation of part of the naphthenes in the feedstock.

The advent of catalytic reforming in 1952 provided a source of cheap hydrogen and stimulated further development of a desulfurization process utilizing external hydrogen. Processes of this type that depend upon the supply of hydrogen from an external source are known under the general term of Hydrofining. In the construction of a 70,000 bbl per stream day refinery at Kwinana, W. A., for Australasian Petroleum Refinery Ltd., an associate company of The British Petroleum Company Ltd., it was decided to include a 5600 bbl per stream day Hydrofiner to produce high quality low sulfur diesel engine fuels.

EXCLUSIVE

Fundamental process data for this unit was provided by The British Petroleum Company Ltd., and the unit was designed, engineered and constructed by M. W. Kellogg Company. The unit is capable of desulfurizing straight run gas oil and blends of straight run gas oil with catalytic cracker cycle oil.

This unit is believed to be the first commercial unit to be specifically erected for the desulfurization of gas oils.

The Process

The Hydrofining process as developed by The British Petroleum Company Ltd. catalytically desulfurizes petroleum distillates with little or no molecular breakdown or reconstruction. In consequence, volumetric yields of 99 per cent and better are obtained. Sulfur in the feed is removed as hydrogen sulfide through reaction with hydrogen over a fixed catalyst bed at temperatures of 760 to 790 F and pressures of 500 to 1000 psi. A high hydrogen to feed recycle rate is maintained in the process to protect the catalyst from excessive coke laydown. As the reaction is only slightly exothermic extensive control of reactor temperature rise is not necessary. Provision is made on the Kwinana unit for quenching the reactor bed with cold recycle gas at two points, but with feedstock containing up to 15 per cent of catalytic cracker cycle oil, it has not been necessary to use this quench gas.

In the construction of the unit all equipment operating at temperatures in excess of 500 F and in contact with hydrogen sulfide, is fabricated in 18/8 stainless steel. Special attention was therefore paid to the unit layout to economize in the use of stainless steel. Valves and control-valve bypasses in the high pressure recycle section are kept to an absolute minimum and all-welded tube construction is used in the combined recycle gas and gas oil preheater. A single downflow reactor of 18/8 stainless steel is used with internal deflector rings to reduce channelling of gas and vapor in the reactor bed.

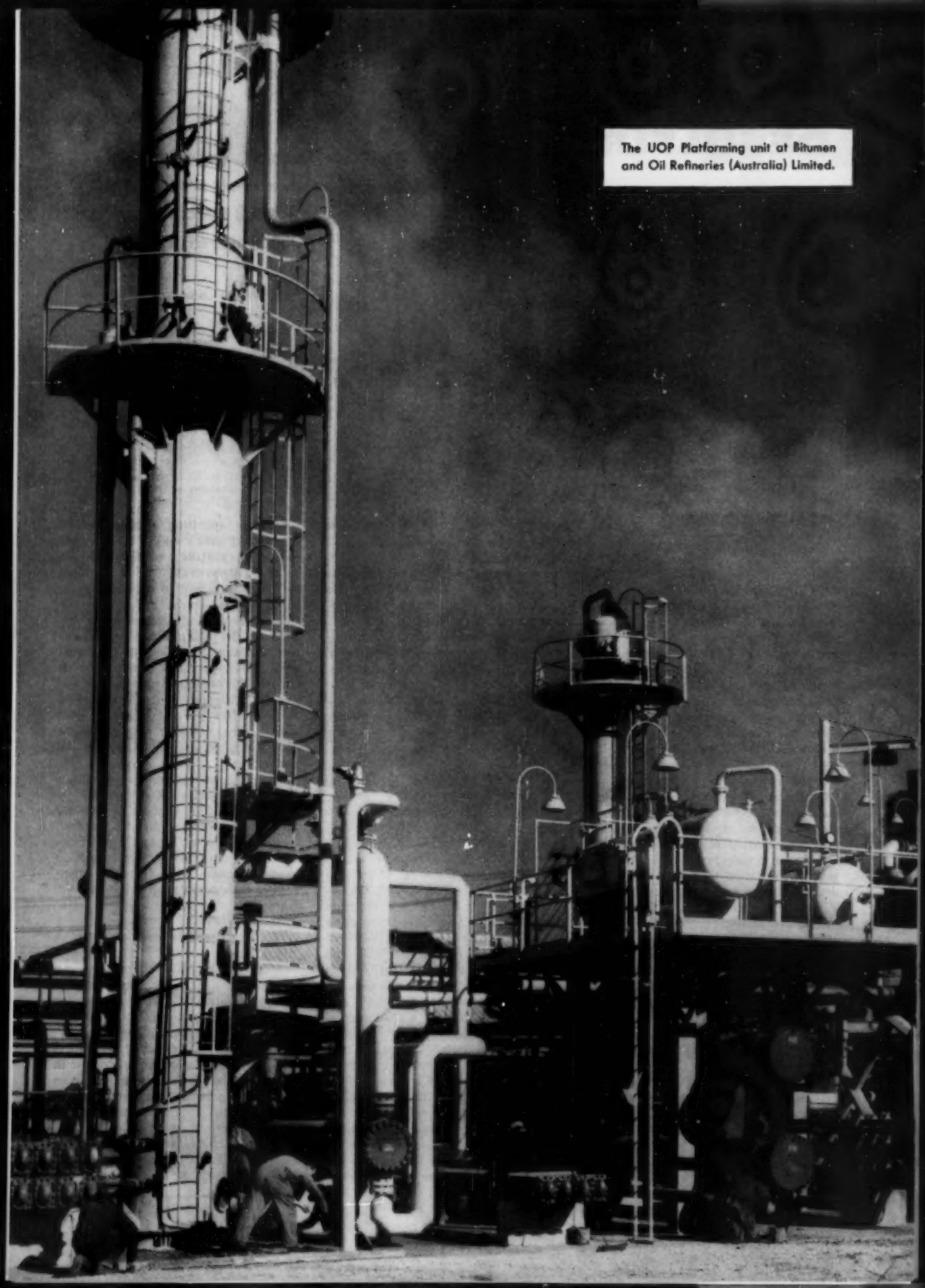
The high catalyst activity enables a high space velocity (cá 8 v/v/hr) to be used, resulting in a small reactor. By the installation of a single thermowell inside the reactor at an angle to its axis, with six thermocouples spaced along its length, the number of openings in the reactor shell is reduced.

Process Flow

The process flow sheet is given in Fig. 1.

The unit consists basically of an adiabatic reactor, a preheater, heat exchange equipment, flash drums for separating gas and product, compressors for introducing and recycling hydrogen and a stabilizer (stripper) column with reboiler heater, for use in stripping the hydrogen sulfide from the liquid product and removing the small quantity of light ends formed in the process.

Fresh feed is taken from floating roof tankage to a feed stripper where a stream of excess hydrogen-rich gas



The UOP Platforming unit at Bitumen and Oil Refineries (Australia) Limited.

Australian Refiner Reports on 3 Years Operation of UOP Platforming Unit

By E. R. Griffin
General Manager
Bitumen and Oil Refineries (Australia) Limited
Matraville, New South Wales

BORAL has the distinction of being the first refiner outside the American continent to install a UOP Platforming unit, and in more than three years it has operated absolutely trouble-free. Since it went on stream in July, 1952, it has been shut down only for inspections and for cleaning or changing catalyst. In our opinion, this remarkable record was not only achieved because of careful operating control, but reflects, as well, the sound processing techniques of operation provided through the application of UOP fundamental basic research and a well designed and engineered process.

E. R. Griffin

The unit at our refinery set a world record for catalyst life, the first charge having lasted for nearly two years. It was dumped on July 1, 1954, having processed 253 barrels of charge per pound of catalyst. A Platformate yield of 94.1 per cent, based on reactor charge, was realized over the entire run and at the time of dumping, it was still making the 72 octane (motor method) standard grade of motor fuel called for in the local market with the addition of only 1.2 cc. TEL. Making such an octane proved to be an easy job for the Platformer even though Middle East naphthas, processed in the unit, generally are among the least desirable charge stocks for catalytic reforming operations.

Now, the standard grade motor fuel has been increased to 79-81 (research), and a premium grade of 90 research octane has been introduced, both of which are being produced by the Platforming unit without difficulty.

The decision to install the Platforming unit, which had an original design capacity of 1,500 barrels per stream day, came after an exhaustive investigation in which it was determined that this process would give us the flexibility we needed in the selection of a charge stock. Our refinery in Sydney then consisted of a 5,000 B/SD two-stage distillation unit and an asphalt converter unit.

A synthetic crude oil, to which was added a small quantity of cracked gasoline, was obtained from the Persian Gulf area for processing into Diesel oil, fuel oil and various grades of asphalt. The gasoline was distilled and sweetened for sale in the local market.

Economics dictated that the processing of whole crude would be more profitable than running synthetic crude because low octane straight run gasoline obtained from whole crude could be upgraded in octane by catalytic reforming with much higher yields than could be obtained by conventional thermal reforming, which was expensive and unsuitable for our requirements.

Having decided to install Platforming, we asked UOP to send an engineer to Australia to assist us in planning for the construction of the unit. Engineering, detailed drafting and purchasing of items not readily obtainable in our country for erection of the Platformer were handled by UOP, which licensed the process. Refinery personnel built the unit.

We decided in 1954 to expand our refining facilities and improve the quality of our other petroleum products. After discussions with UOP on the best course to follow, we concluded that the Unifining process would be most adaptable to our needs. Universal was requested to prepare the engineering and detailed drafting and to purchase hard-to-get items as well as to prepare the design and engineering for revamping the Platformer to increase its capacity to 2,500 B/SD, and to prepare the process designs for a 10,000 B/SD topping plant.

Exhaustive work in Universal's laboratories resulted in the design of a "tailor-made" Unifining unit which processes a combination of Diesel fuel and aromatic light oil produced from an oil gas plant located in Sydney. The Unifining unit has made BORAL one of the first refiners in the world to offer Diesel fuel purified by the use of hydrogen.

In conclusion, we would like to say that our association with UOP not only has enabled us to keep abreast of the most modern refining techniques, but it has made available to us technical "know-how" which has proved invaluable.

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Forty Years Of Leadership
In Petroleum Refining Technology

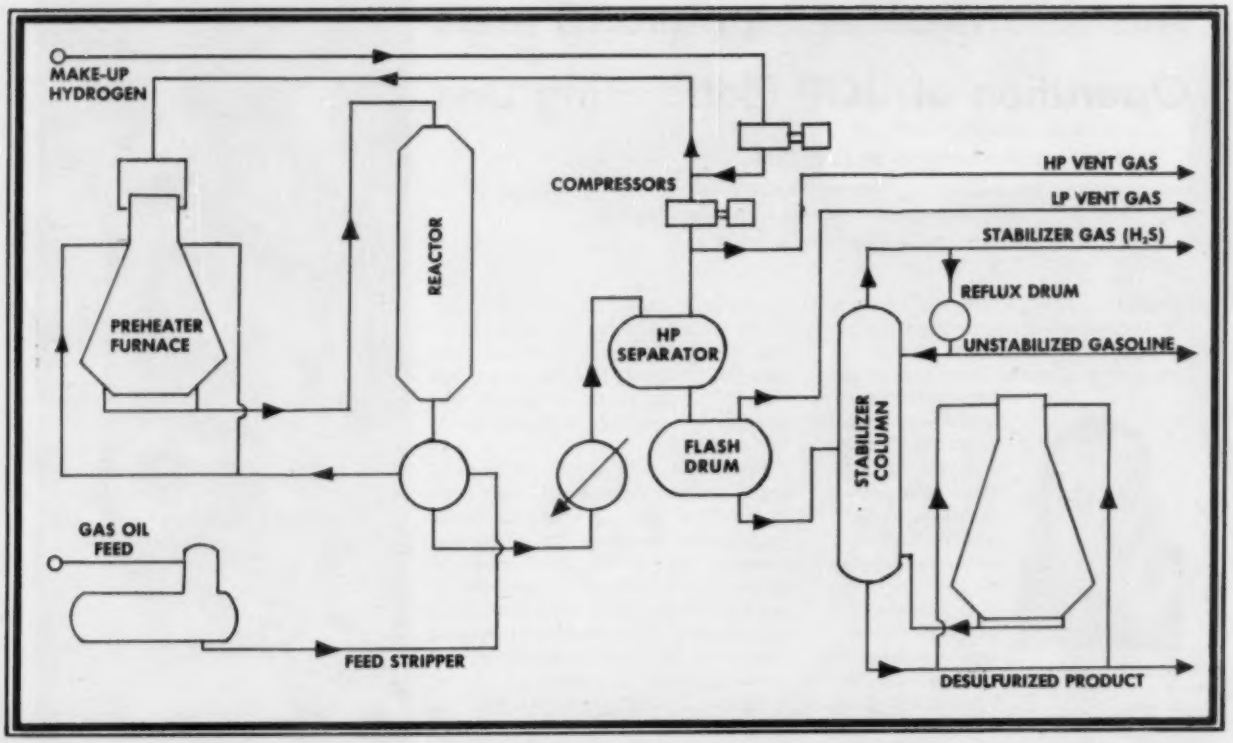


FIG. 1. **Process Flow** in the Kwinana Hydrofiner Unit.

from an adjacent catalytic reformer counter-currently strips out any dissolved air to minimize gum formation and fouling of the feed-reactor effluent heat exchangers. From the stripper surge drum, the feed is split into two streams for heat exchange with hot reactor effluent. The recycle gas is heated in the convection section of the preheater, being joined by the gas oil feed for further heating in the radiant section. The combined furnace streams enter the top of the reactor, largely in the vapor form, at 760 to 780 F and 1000 psi. After exchange with gas oil feed, the reactor effluent is cooled in water coolers, and passes to the high pressure separator where the recycle gas is separated from the liquid product. The gas stream is recycled by two horizontal steam driven compressors. Make-up hydrogen-rich gas is here injected into the recycle system from the nearby catalytic reformer.

The liquid stream from the high pressure separator is partially flashed off in the flash drum at 250 psi before heat exchanging with stabilizer bottoms and entering the stabilizer column. Additional heat is supplied to the column by a fired reboiler heater. The overhead vapors are partially condensed and enter the reflux drum. The uncondensed vapors containing a high percentage of hydrogen sulfide pass direct to the flare system for burning, while the condensed liquid is refluxed and the net overhead product pumped offsite as unstabilized gasoline. Desulfurized gas oil as stabilizer bottoms passes through a bottoms-feed exchanger followed by water coolers. Provision is made to wash the gas oil product with 10 per cent caustic soda in the event of hydrogen sulfide still being present after stripping in the stabilizer column.

The Catalyst

The present catalyst charge consists of cá 9000 lb of pelleted cobalt and molydenum oxides on alumina supported on ½-in. or 1-in. ceramic balls. The pelleted catalyst was chosen in preference to a granular one because of its better physical properties such as crushing strength and desulfurization efficiency and also because it was more economical for the catalyst manufacturers to produce. The size of the pellets were such as to give a low pressure drop across the catalyst bed and so economize in compressor equipment and utilities.

The Hydrofining catalyst is particularly robust and has proved resistant to poisoning and contamination. Process upsets or contamination in the feedstock which might tend to laydown coke on the catalyst cause only a temporary loss of activity which is readily regained on regeneration.

Process Operation

The Kwinana unit, the first of its type, was commissioned early in 1955. Operation to a total of more than 3500 hours has confined sulfur removals of better than 90 per cent on Middle East gas oils containing up to 1.2 per cent weight, of sulfur. Typical operating conditions and inspection data are given in Table I. The high speed fuel market in Australia and New Zealand demands a sulfur content of 0.1 per cent which is readily obtained from this Hydrofining unit under normal operating conditions.

From an operator's viewpoint the Hydrofining process is flexible and easy to control; the Kwinana unit is

TABLE 1.

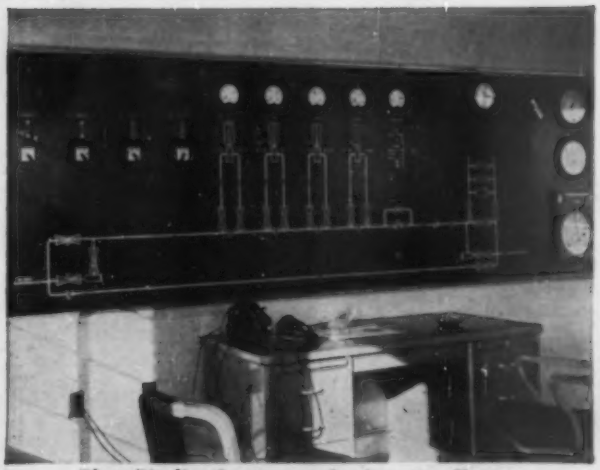
Typical operation		
Hours on stream	50	1045
Operating conditions		
Feed rate (B.P.S.D...)	5510	4200
Space velocity (v/v/hr)	7.9	6.0
Reactor temp. (°F)	780	780
Reactor pressure (psi)	1000	900
Recycle gas rate (SCF/B)	4400	4400
Yield (vol. %)	99.5	99.0
Yield (wt. %)	98.0	97.8
Inspection data		
Feedstock		
Specific gravity (60 F)	0.842	0.842
Sulfur content (% wt)	0.97	0.94
Product		
Specific gravity (60 F)	0.830	0.832
Sulfur content (% wt)	0.08	0.08
Desulfurization (%)	91.7	91.5

When control lines run out-of-doors, instrument air must be DRY

NO DANGER of freeze-ups here to cause instrumentation and air motors to fail. Although this compressor draws in humid, outdoor air, the receiver discharges through the Lectrodryer. It removes every trace of moisture to dewpoints well below the coldest weather encountered here in Kansas.

Lectrodryers come in sizes to suit every DRYing requirement; for low or high pressure work. They can be made fully automatic, although the only attention a Lectrodryer usually needs is periodic reversing of a valve. This puts one column on regeneration, while the other is DRYing, a cycle that's repeated day after day, year after year.

Bulletin 223-A describes these instrument air driers. For a copy, write Pittsburgh Lectrodryer Company, 334 32nd St., Pittsburgh 30 Pennsylvania (a McGraw Electric Company Division).



Platte Pipeline Company station in eastern Kansas: valves are air-controlled and air-operated.

This little Lectrodryer removes all moisture from the compressed air going into the system.*

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
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LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

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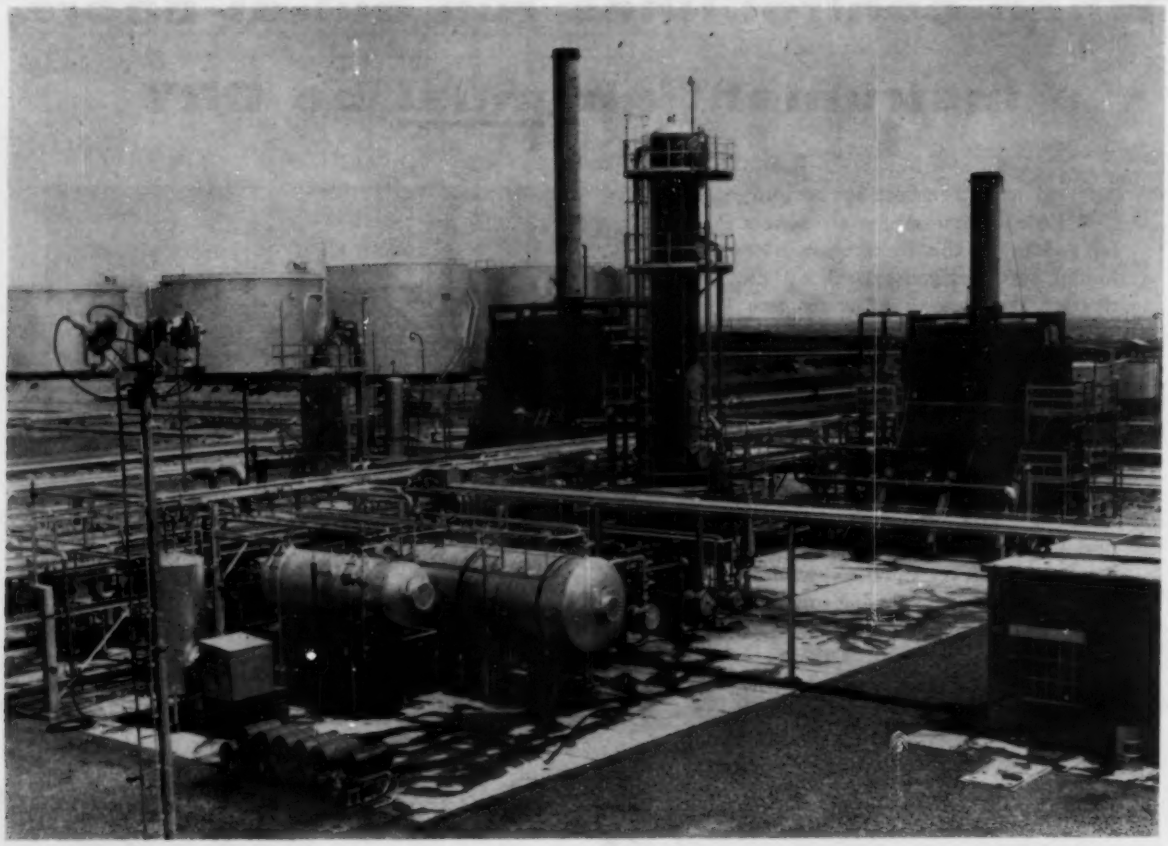

FIG. 2. **Good Housekeeping Nearly Always** bespeaks efficient operation; here the Kwinana Hydrofiner takes sulfur out of gas oils, with the reactor and heaters in the background; flash drum, caustic wash system and the stabilizer in foreground. Even the oil drums have "cradles."

manned by one operator per shift. Unlike some catalytic processes where the necessity to protect the catalyst imposes narrow space velocity limits, the Hydrofiner throughput can be adjusted to suit the refiner's market requirements at the time.

Start up of the unit is not complex and commences with a methodical purging of the complete reactor and recycle gas system. Ample purging time and a careful check by Orsat analyses at several points in the gas recycle system ensures the complete absence of oxygen before hydrogen-rich gases are admitted for pressuring the unit. Gas recycle is established and the catalyst bed brought to a temperature of 650 F. minimum. Gas oil feed is then slowly introduced to join the recycle gas in the combination preheater, and passes forward to the reactor, separator and stabilizer sections. Gas oil is recirculated to feed until normal operating temperatures and pressures are reached and as a result no off-specification gas oil product is made during startup. This gradual start-up procedure avoids undue high temperature stress of piping and flanges. To prevent contamination of the product with feed, double blockvalves with intermediate vents are installed on the bypasses of these exchangers.

Pressure drop over the reactor is normally 10-12 psi at full throughput. Use of stainless steel in all high temperature equipment contributes to the low pressure drop in avoiding the formation of sulfide scale that would otherwise carry forward in the combined recycle gas and oil stream and settle as a pad on top of the catalyst bed.

The hydrogen recycle rate has not been found critical in operation, although a normal rate of 4000 std cu ft per barrel of feed is maintained. In the event of one of the recycle gas compressors being out of service the unit has operated with a recycle rate of 2000 std cu ft per barrel for a short period with no detrimental effect on the catalyst activity.

Hydrogen consumption in the process varies with the type of feedstock and the degree of desulfurization required. On a straight run gas oil containing 1 per cent sulfur, a sulfur removal of 90 per cent requires cá 150 std cu ft per barrel.

A useful hydrogen concentrating effect of 2-3 per cent occurs in the recycle gas in the high pressure separator due to the greater solubility in gas oil of the light hydrocarbons entering the system in the hydrogen-rich make up gas.

The stabilizer section of the unit, including the two flash stages operates efficiently, removing light hydrocarbon vapors and hydrogen sulfide from the product. In consequence the caustic soda consumption for caustic washing the desulfurized product has been almost negligible and is commissioned only in the event of a major upset on the stabilizer column. The stabilizer overhead gas containing 30-40 per cent mol hydrogen sulfide, is burnt at the flare.

Catalyst Regeneration

The end of a processing cycle is determined by a reduction in desulfurization activity and is followed by a simple once through steam-air regeneration of the catalyst to remove carbon and sulfur deposits.

The regeneration cycle is commenced by cutting the gas oil feed to the unit and depressuring while cooling reactor to 700 F with circulating

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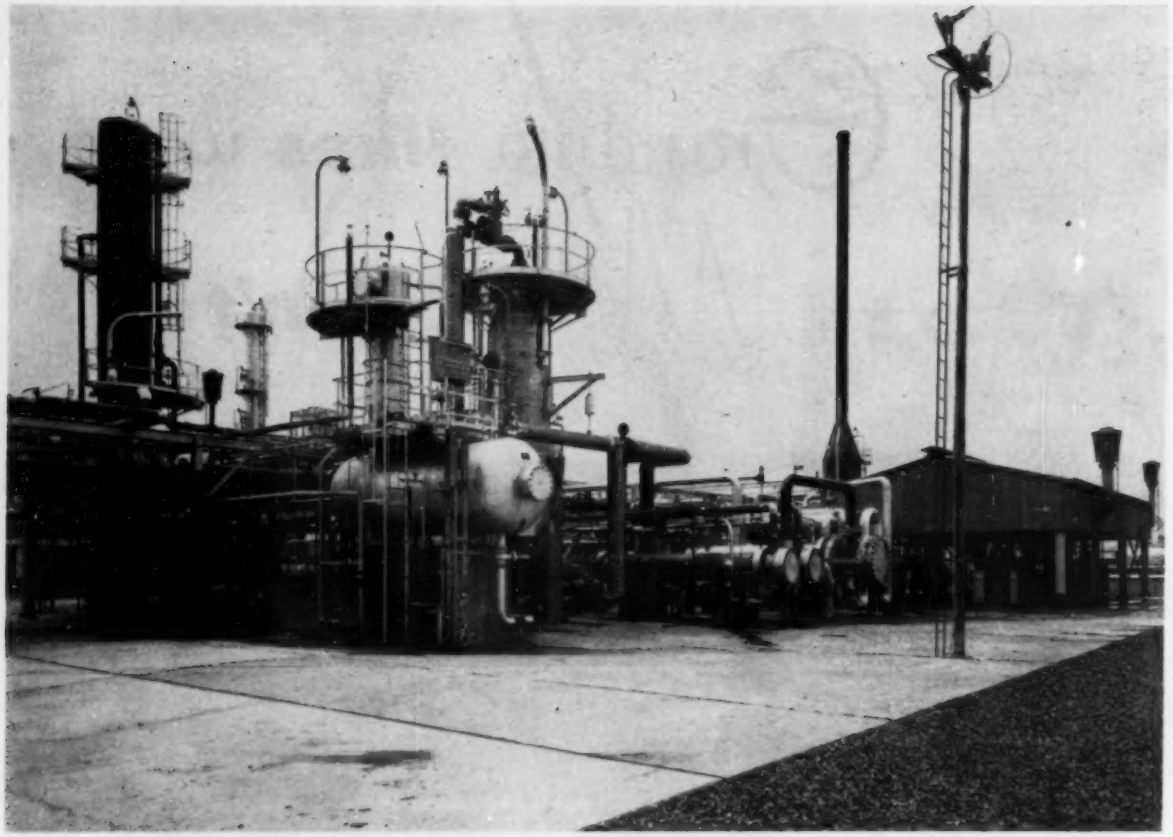


FIG. 3. **"Open Work" Compressor Houses** are the vogue in Australia, if this photo is to be believed; feed stripper is in the foreground, here; heat exchangers and reactor in center group.

recycle gas. The recycle system is then purged with inert gas while the necessary blanks are changed to admit air and steam, and to divert the exit regenerated gases to the preheater stack. Steam is superheated in the preheater to heat the catalyst bed to 700-800 F before introducing a small flow of air.

An immediate rise in catalyst temperatures occurs on injecting steam to the bed due to reaction of the steam with sulfur compounds present on the catalyst. The progress of the flame front during regeneration is readily followed from the reactor bed temperature recorders and is controlled below a maximum of 1100 F by adjustment of the steam-air flow ratio. Regeneration is considered complete when the acid gas content of the uncondensible effluent gases falls below 0.1 per cent volume.

The time required for regeneration is a function of the coke laydown on the catalyst, the flame front temperature, and the steam and air flow. The normal time on the Kwinana Hydrofiner is 24 hours. Strategic placing of blanks to permit a quick change over from the process cycle has considerably reduced the time for change over.

After completion of regeneration, and purging of the recycle system, care is taken in introducing hydrogen to the hot catalyst bed, now in the oxide state, as a considerable exothermic reaction ensures. This is offset by recycling hydrogen through the reactor at an initial pressure of 100 to 200 psi.

Full catalyst activity is regained following regeneration as shown in Table 2. The ultimate catalyst life is definite although it is expected to exceed three years from comparison with a similar type of catalyst now in use in an autofining unit at one of British Petroleum Company refineries in the United Kingdom.

Conclusion

The Hydrofining of Middle East straight run gas oils by The British Petroleum Company Ltd. process results in a consistent desulfurization of better than 90 per cent, enabling product sulfur contents to be maintained below 0.10 per cent weight. The resulting product has favorable high speed diesel fuel market properties; a low sulfur content and carbon residue, and a high diesel index. By including catalytic cracker cycle oil in the feedstock, the specific gravity and pour point can be further improved.

The process makes use of catalytic reformer hydrogen-rich gas which would otherwise go to refinery fuel gas. The catalyst is readily regenerated but normally has a long run life between regenerations. With the present rapid increase in catalytic reforming capacity and the attendant high production of hydrogen-rich gases, the Hydrofining process has extensive possibilities. Future expansion in both throughput capacity and type of feedstock processed can be confidently predicted.

TABLE 2.

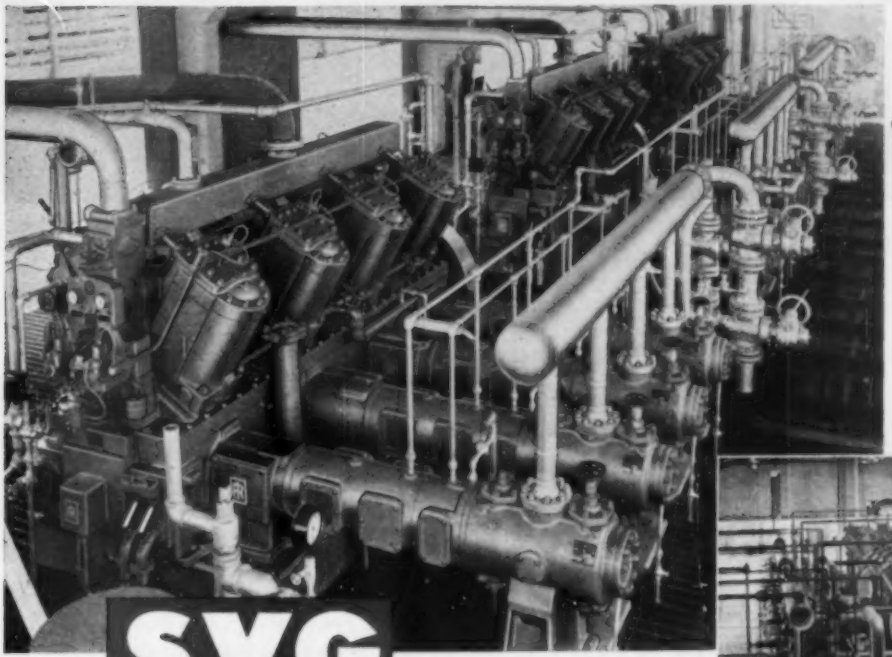
Operating conditions	Before regeneration	After regeneration	
Feed rate (BPSD)	3120	4180	5360
Space velocity (v/v/hr)	4.5	6.0	7.7
Average reactor temp. (°F)	780	780	780
Reactor outlet pressure (psi)	1000	1000	950
Feed sulfur content (% wt)	1.00	0.97	0.90
Product sulfur content (% wt)	0.09	0.05	0.08
Desulfurization (%)	91	95	91

Acknowledgment

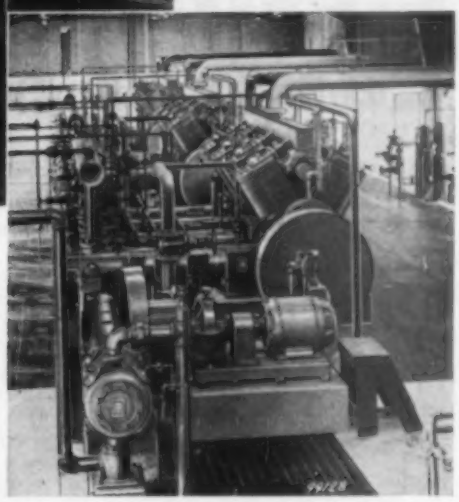
The authors wish to thank the chairman and directors of the Australasian Petroleum Refinery Ltd. and of The British Petroleum Company Ltd. for permission to publish this paper. ★ ★

in CATALYTIC REFORMING too,

Ingersoll-Rand gas-engine compressors offer important advantages



At Pontiac Refining Corp., Corpus Christi, Texas, these three Ingersoll-Rand SVG gas-engine-driven compressors recirculate 85.8% hydrogen gas for the U.O.P. Platforming Unit built by Procon, Inc. NL cylinders with graphitic carbon wearing and compression rings and double compartment distance pieces, provide full protection against oil contamination of the reforming catalyst. Each unit rated 440 hp, 450 psig intake, 610 psig discharge.



At Great Southern Chemical Company, Corpus Christi, Texas, these three I-R 440-hp SVG units are also serving a Procon installed U.O.P. Platformer, compressing 90% hydrogen from 190 to 370 psig. Here, too, I-R non-lubricated cylinders and distance pieces are used to keep oil out of the gas stream. Capacity and pressure are controlled by variable engine speed plus hand-operated inlet unloaders.

Compressors for catalytic reforming service are subject to wide variations in speed and load—and the compressed hydrogen gas must be kept entirely free from oil, to avoid contamination of the catalyst.

Both of these conditions are met to excellent advantage by Ingersoll-Rand SVG compressors. The inherent stability of the V-type *four-cycle engine* assures smooth, dependable power all the way from no load to full load, at anywhere from half speed to full rated rpm.

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Whatever the job, it will pay you to look into these basic advantages of the SVG compressor. Ask your I-R representative for the complete story. Or write for Bulletin 3128-A.

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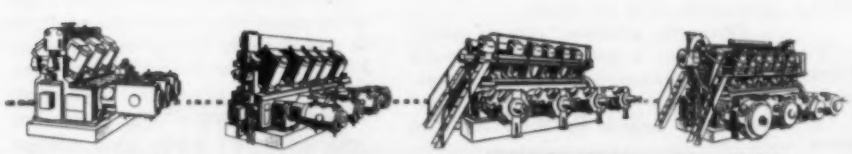
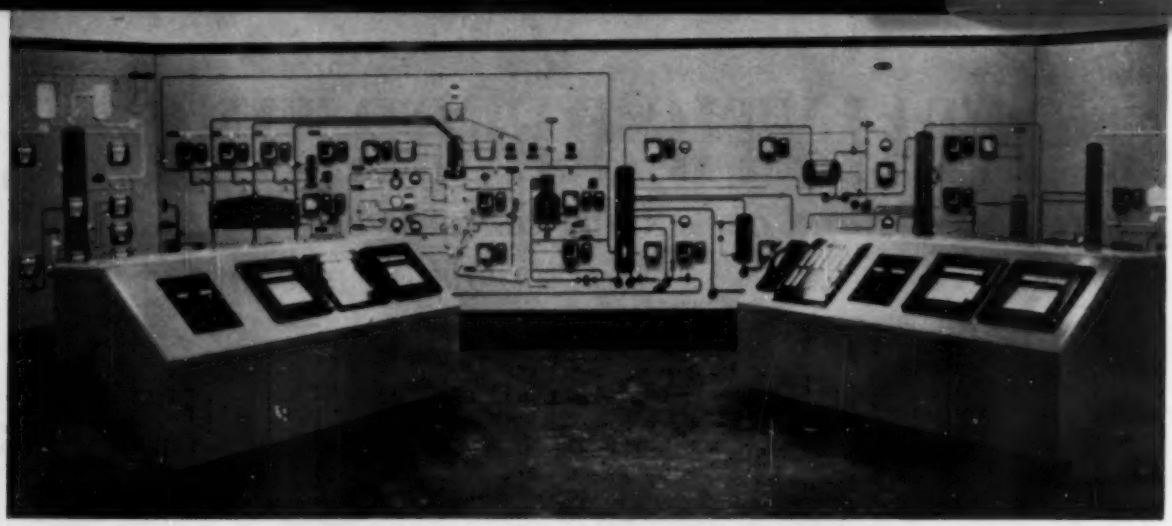




Typical American Electronic Process Control System.

P 740.1

The new type of controls will be the standard system of the future

Electronic Process Control System

Karl W. Peterson
Maxwell, Manning & Moore, Inc.

IN spite of the far reaching developments in control systems, there are many requirements that have not been met in present day equipment. A number of these requirements are:

1. Some process variables cannot be adequately controlled due to the time-lag inherent in present day equipment. In many applications what appears to be smooth control is an indication of slow response of the control system.

2. Artificial capacities are built into the equipment to permit control of variables which increases the cost of the equipment and reduces productivity.

3. Location of the instruments is many times compromised by limitations in the practical transmission distance. It is often necessary to place controllers in the field where it is desirable to operate from a centralized location.

4. Installation cost often equals or exceeds the cost of the instrument equipment.

5. Costly and troublesome air supply equipment (compressors, driers and piping) is required by present pneumatic instruments.

6. Shorter start-up and down times would be preferable. Reducing these factors alone can save the cost of the instrument equipment.

7. Data on the process variables and operation are many times not presented in a readily usable form. The chart records and log sheets must be analyzed and translated by human interpreters.

Several of these shortcomings have been overcome by a new electronic system which offers faster measurement and control responses and reduced transmission lags. Through the use of electronics distances up to 30 miles are possible between the process and the control room. These systems are also compatible with electronic computers, calculators and business machines that presently are being used to analyze data and present it in its most useful form. Since the devices are fundamentally electrical, electronic measuring and control instruments may be used to feed signals to them. This is important since it is envisioned that plants of tomorrow will use automatic data reduction devices to keep pace with plant operations.

Obviously, electronic process instruments make it possible to go beyond present techniques and practices. Achievement of the "push-button" plant will depend on the acceptance and added development of these new electronic systems.

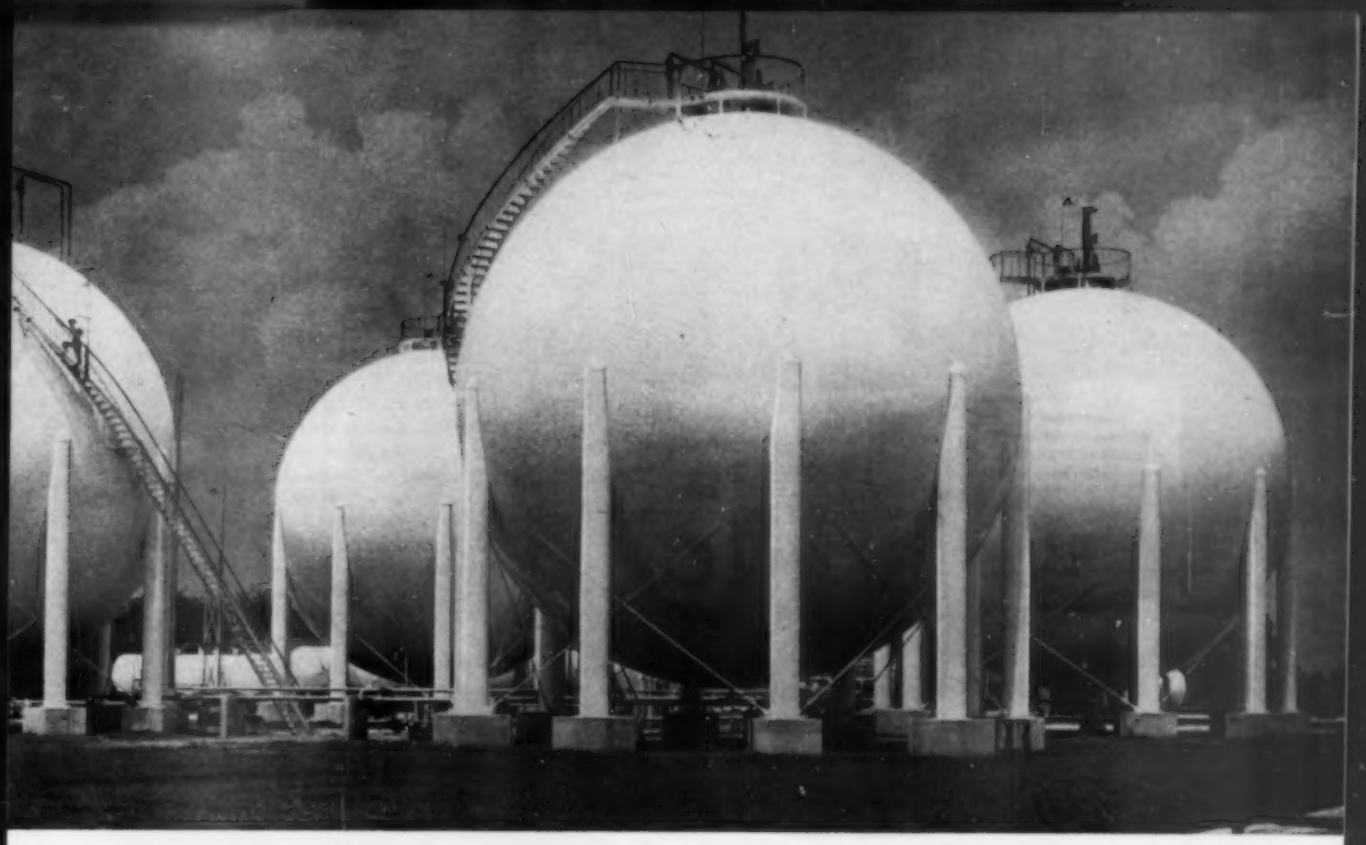
EXCLUSIVE

If it is accepted that electronic process control and measurement will be the commonly used system of tomorrow, it is well to examine some of the ideas that went into its development and the techniques of working with it.

At the start of the design problem several types of signals were available. The first choice was between alternating and direct current.

Direct-current instruments are generally more expensive to build but would have a number of advantages. Their inherent accuracy is better and signals would not be affected by a-c induced from the power circuits that cobweb most plants. It allows the use of unshielded transmission cable even placing the signal wiring in the same conduit with 115-v, 60-cycle lines. The lower installation cost resulting would more than offset the higher cost of the equipment. Direct current was selected for signal transmission.

Having chosen direct current, engineers settled on a current type of signal in preference to voltage or time-pulse. First, it is continuous which time-pulse is not. Second, signals can be compensated for changes in transmission line resistance more easily than voltage signals. In addition most electrical de-



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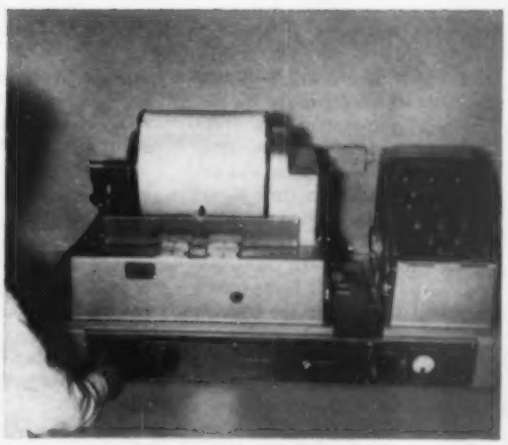
For further information, consult your nearest Du Pont Sales representative or write: E. I. du Pont de Nemours & Co. (Inc.), Finishes Division, Wilmington 98, Delaware.



FINGERPRINTING A FINISH. Here a Du Pont chemist uses infrared transmission spectrometer to identify and control chemical characteristics of resins, oils and finishes. The pattern it gives is like a fingerprint and may be used to trace extent of reaction that occurs in the manufacture of a resin.

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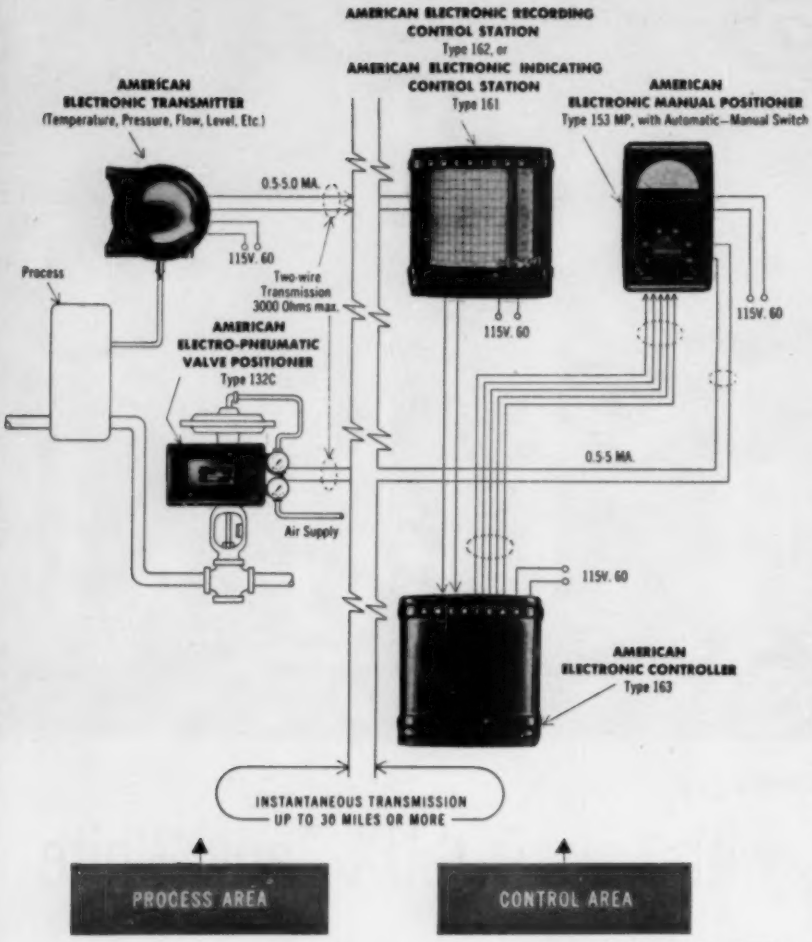

— *Courtesy Canadian Petrofina, Ltd., Montreal.*

New control system on a graphic panel installed in Canadian refinery.

vices with which the system would be used are made to fixed *voltage* ranges.

The heart of the system is a beam type balance servo-amplifier unit. In the system a servo-amplifier was developed to build up the tiny signal (motion or force) produced by most measuring elements.

Purpose of this unit is to transduce a mechanical or electrical force into a d-c current signal. The device consists of a light, dynamically-balanced beam with flexure pivots. Input force from a measuring element causes one end of the beam to move in the vicinity of a tuned oscillator coil. Movement of the beam causes detuning of the oscillator so that more or less current flows through a vacuum tube associated with it. A portion of the current is fed back to a coil in a magnetic field near the free end of the beam. This produces a force on the beam to oppose the input force and move the beam back toward its original position. The beam is force-balanced by this feedback, thus assuring a precise relationship between input force and output signal. In this manner the feedback system compensates for the effects of line voltage variations, ambient temperature changes, tube deterioration and circuit resistance changes. A unit of this type had been used for some time in Aircraft engine control systems.

The signal transmitted is a d-c current of 0.5 to 5.0 ma for fullscale range of the input signal. The signal can be transmitted over long distances — provided the total resistance of the transmission circuit does not exceed 3000 ohms. This is approximately 30 miles using No. 18 AWG wire. Since the transmission line originates in the plate circuit of the vacuum tube, it has a very high source resistance.

This means that large changes in transmission line resistance result in little error in measurement — less than ½ per cent for 3000 ohms variation.

Many accessory devices have fixed voltage ranges, such as potentiometer recorders, digital read-out systems, monitors, computers, etc., which can be fed by the transmitter with no effect on the overall accuracy or operation. To accommodate these devices, a calibrated resistor, of any value up to 3000 ohms, is inserted into the transmission line. The voltage drop across this resistor is a measurement of the process variable.

Transmitters

Pressure. The above transmitter is used with Bourdon and bellows elements for pressure measurement. Pressure ranges have been accurately measured from 40 in. of water (using a bellows element) up to 30,000 psi.

Flow. Differential pressure, for flow and level, is measured by a bellows differential unit, with accuracy from 20 to 400 in. of water, and with static pressure ratings to 5000 psi.

Temperature. Filled thermal system for range spans from 50 to 1000 F have been designed. For spans above 200 F, thermocouple input transmitters are also used — for temperatures up to 3000 F.

Level. Levels can be measured by the Bourdon or differential pressure elements, and also by displacement and float-operated level units.

Electrical. The electrical input transmitters can be used for voltage or current measurements down to 100 microamperes for full scale range. They are compatible with most of the electromatic transducers for such measurements as pH, oxygen concentration, gas analysis, etc.

Transmitters are housed in appropriate cases for all conditions of installation. A general purpose case is used for ordinary indoor use. A weatherproof case permits outdoor mounting. An explosion-proof case, meeting Class I, Division 1 requirements, has been designed for use in hazardous areas.

Receivers

Conventional milliammeters, range 0.5 to 5.0 ma, are capable of indicating signals. For convenience, scales are calibrated in terms of the variables being measured—flow, pressure, pH, etc.

However, for maximum accuracy and response, a line of special indicators and recorders has been developed. These operate very nearly like the transmitters. The difference is that the output signal is fed to a powerful rotary solenoid which moves the pointer or pen. Movement of this solenoid also provides the feedback force to rebalance the beam. Thus, the balance measures pen or pointer position, compares it with the input signal, and eliminates any discrepancies between the two. The pointer is thus dynamically held at the correct reading.

Indicators. Milliammeter receivers are in use in many different forms and sizes. Servo-type indicators have been designed.

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Recorders. For conventional uses, a 10 in. diameter recording receiver is used. This instrument records on a 10-in. diameter chart in terms of the variable being measured.

However, the trend toward using strip-chart instruments is strong, and a more popular type of receiver is a 3-in. strip chart recorder. This instrument is housed in a panel-mounting case which occupies less than 25 sq in. of panel space.

Control System

Having designed the basic measuring and recording equipment the control system developed (shown in Fig. 1) follows the miniature, unitized design. All control responses are entirely electrical; there is no mechanical motion.

Set Stations. The first unit in the control system is the indicating or recording set station. This component serves two functions. It provides indication or recording of the process variable, and it provides an output signal proportional to deviation of the process variable from the set point. The recording (or indicating) section operates exactly the same as the 3-in. strip chart recorder.

The set point function is obtained by comparing the value of the measured variable with the position of the control point setting mechanism. This manually set pointer applies a force to a solenoid balance opposing the force caused by the measured signal. When the measured variable is at the desired set point, the forces cancel. When it is not at the set point, an error signal is created. This error signal (—22 v to +22 v) tells the direction and degree of the deviation from the desired set point. This error signal is sent to the next unit in the system: The electronic controller.

Controller. This unit is essentially an electronic amplifier with feedback circuits arranged to give proportional and reset control actions. When rate (derivative) response is required, a preamplifier is inserted into the circuit to provide this action.

There is, of course, no mechanical link between the recording instrument and the controller. The response of the controller is completely independent of any mechanical movement. Entirely electrical, it is capable of extremely fast control responses. Since the electrical components are easily held within close tolerances, reset and rate settings are calibrated.

Manual Station. The output of the controller goes to a manual control station. This device permits switching from automatic to manual operation of the control valve under start-up or emergency conditions. It is simply a current regulator that, under manual operation, sends a constant, manually set signal to the final control element.

Valve Positioner. When conventional diaphragm valves are used the final link in the electronic control loop is the electro-pneumatic valve positioner. This device is mounted and linked to the pneumatic topwork which moves the valve stem. It transduces the 0.5 to 5.0 milliampere signal to a pneumatic pressure of up to 25 psi to operate the valve.

In addition to the electro-pneumatic valve positioner, an electrohydraulic valve operator has been developed. Electro-hydraulic valve operators have distinct advantages over air operated control valves in that they can be used in locations where air pressure is not readily available to the installation, such as in pipe line service or on processes where the cost of supplying and maintaining adequate air supply is costly.

Another advantage of electro-hy-

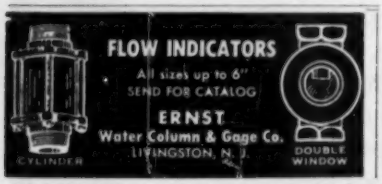

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FIG. 3003—Steel Gate Valve For 300 Pounds W.S.P.

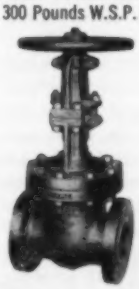


FIG. 375—Bronze "White Star" Gate Valve For 200 Pounds W.S.P.

FIG. 3059G—300-Pound Steel Lubricated Plug Valve Gear Operated. Sizes 6" to 12".

POWELL VALVES

BRONZE, IRON, STEEL AND CORROSION RESISTANT VALVES.

draulic control valves is their suitability to installations where a centralized control room is desirable, but not available to pneumatic control systems because of distance limitations of air control signals.

The unit is equipped with a ⅙ horse power electric motor and gear pump to provide a continuous flow of fluid which is maintained at approximately 500 psi by a relief valve. The fluid flow is directed to a power cylinder by an extremely sensitive four-way pilot valve. The pilot valve features frictionless suspension of the moving member and the ability to apply the full supply pressure across the piston with a very small displacement.

The pilot valve position is determined by a balance of input force generated by a coil in a magnetic field and feedback force developed by a spring. By this design, the input signal of only .5 to 5.0 ma (40 milliwatts) positions the valve with accuracy. Stalled force is over 1200 lb in each direction and at any stem position speed is ⅓ in. per second; stroke is three inches, and a stem load of 500 lb produces less than 1 per cent offset. When set for ½ in. stroke, the response is uniform to 1 cycle per second and lag is approximately 60 deg at that frequency.

Versatility of Electronic Controls

The basic units described here can be mounted and used in many different ways. Since there are no mechanical connections between units, there are almost unlimited possibilities.

Mounting. First, the distance between transmitters and receivers can be as much as thirty miles. Consequently, controls for many widely separated units can be centralized. For example, several pumping stations can be controlled and their variables measured at a central station, saving much travel in collecting records and also wasted time in emergencies.

Within the control room, the controllers can be mounted anywhere — on the main panel or on the skirt, so all adjustments are made from the front of the panel. Or they can be rack-mounted at the rear of the panel enclosure.

There is no real need to mount any of the units on the face of the panel, if that is not desirable. For example, manual positioning stations can be mounted on a desk console, at the fingertips of the operator. Control point deviation meters can be mounted in the same way. Some visualize a control room in which deviation meters and manual stations are lined up on the desk where the operator can check them all at a glance. When something happens to the control system, it can be immediately turned to manual operation.

Data Presentation. Although the indicators and recorders described here follow conventional graphic design, other data handling equipment is used in conjunction with the system. The first major installation of this equipment incorporated a digital recording and monitoring system for critical variables. Similar systems can be used to record the data, to operate alarm and annunciator systems when process deviations occur, to store data for future use, to feed data to computors, etc. This field has not been explored yet but appears to have tremendous posibilities.

Where panel space is very limited when chart records are required, the data can be recorded on multi-point potentiometers. A "sub-miniature" set station is available to conserve panel space. With such an arrangement 8 to 12 variables can be controlled and recorded with equipment contained on a 24-in. panel width.

Control Actions. Electrical systems can be built to incorporate many different responses. Thus, electronic controls are not tied down to the usual control actions of conventional systems.

For example, an electronic control system has been built to have, in effect, a wide proportional band when the variable is close to the set point and a narrow band as it moves beyond set limits. This particular instrument was used to control gas pressure while flow of the gas was continuously integrated. The idea was to allow the pressure to vary within reasonable limits so there would be no abrupt changes in flow. But as pressure approached the limit, the proportional band would narrow, thus holding within the limits at the expense of larger changes in flow. The gradual flow changes during normal operation made it possible to integrate the records with great accuracy.

This is just an example of what can be done. Similarly peculiar control actions might be designed to suit other special requirements.

Another new instrument is an electronic program controller. The programmer resets the control point across the scale electrically at a rate that is continuously adjustable. The rate of programming can be established by a separate signal, as from another controller. This is useful in a process where, say, the pressure must be cycled between limits to create a reaction, but where the cycle must be slowed down if the process temperature exceeds a safe value.

Cascade control systems can be set up using completely standard components. The control signal from the primary controller is fed into the input of the secondary controller.

Ratio control is accomplished with a unit which retransmits some fraction or multiple of its input signal. In flow ratio control, for example, the primary flow transmitter feeds its signal to this ratio amplifier unit which retransmits its signal to reset the secondary controller. In this way, the flow controller is positioned to follow the variations of the primary flow transmitter according to a manually set ratio.

Installation, Operation of Electronic Controls

Installation. The control unit is furnished with a preassembled cable for connection to the set station and the manual station. Panel connections are made simply by connecting this cable to the appropriate terminals. Obviously, a great deal of time and materials are saved.

Connecting the panel equipment to the field mounted transmitters is a matter of wiring. Since direct current is used ordinary unshielded wiring is used. Inexpensive multi-conductor cable is entirely satisfactory.

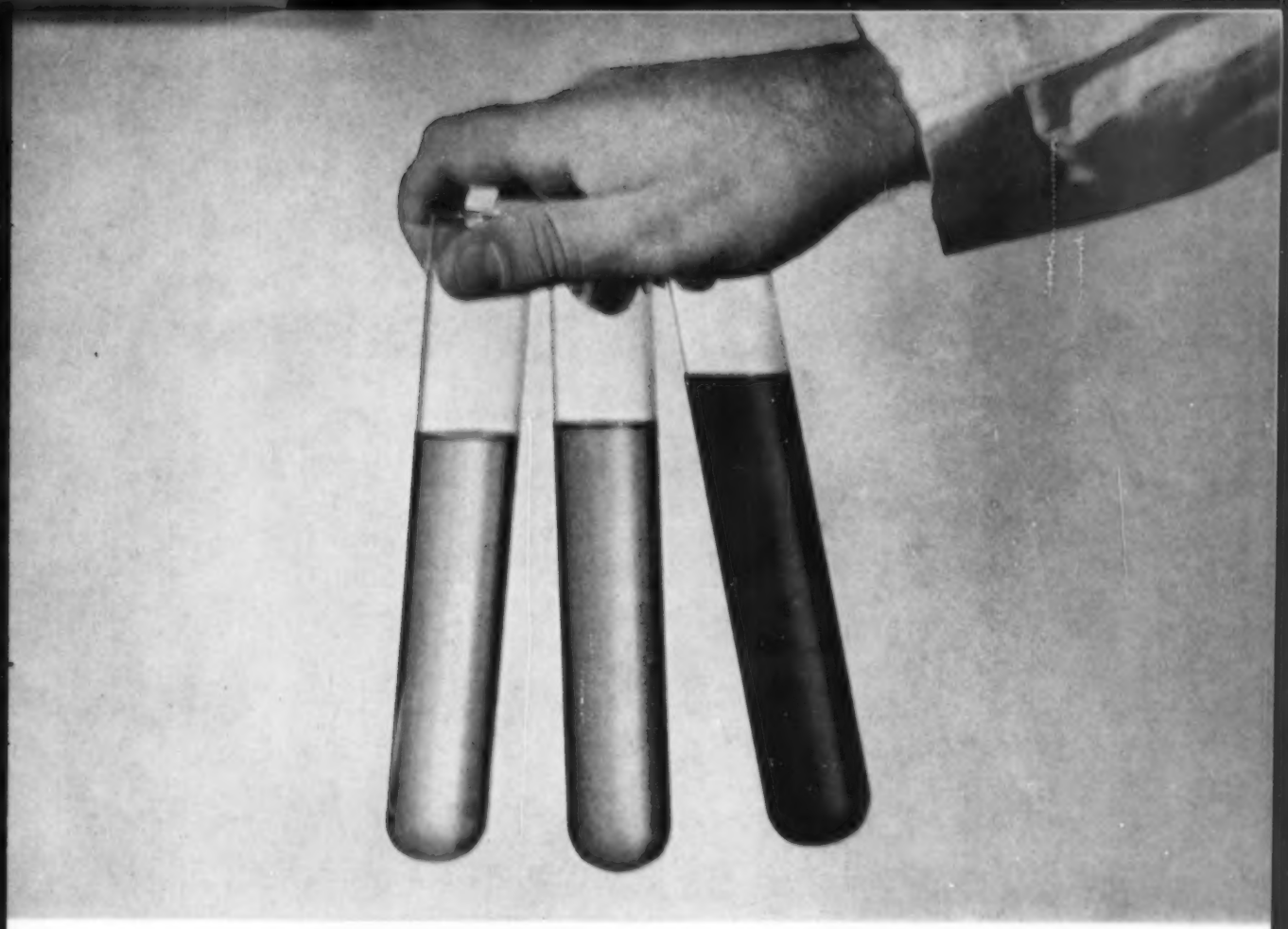
Many different types of cables are available, some for conduit installation, some with self-supporting messengers. When conduited wiring is required, a large conduit with multi-conductor cable is run to a strategically located junction box in the field, and smaller conduits take off from this. The saving in such an installation is made in running the cable — all communcation lines are pulled into the conduit at the same time. Power supply wiring can be in the same cable with the signal lines.

Just as pneumatic controls prevailed by overcoming limitations of the old, on-off electric controllers, electronic controls will become the standard system of the future. ★ ★ ★

The Author

Karl W. Peterson joined the Bristol Company as sales engineer and application engineer soon after receiving his B.S. in chemical engineering from Penn State. Since that time he has served 19 years in the sales or engineering end of the instrumentation field. He was sales manager for CDS Control Services before joining Manning, Maxwell & Moore, Inc., in 1954 as product manager.

In 1955, Peterson was named sales manager, industrial controls division, when a separate division was formed to design, manufacture, and market the company's American-Microsen electronic process control system.



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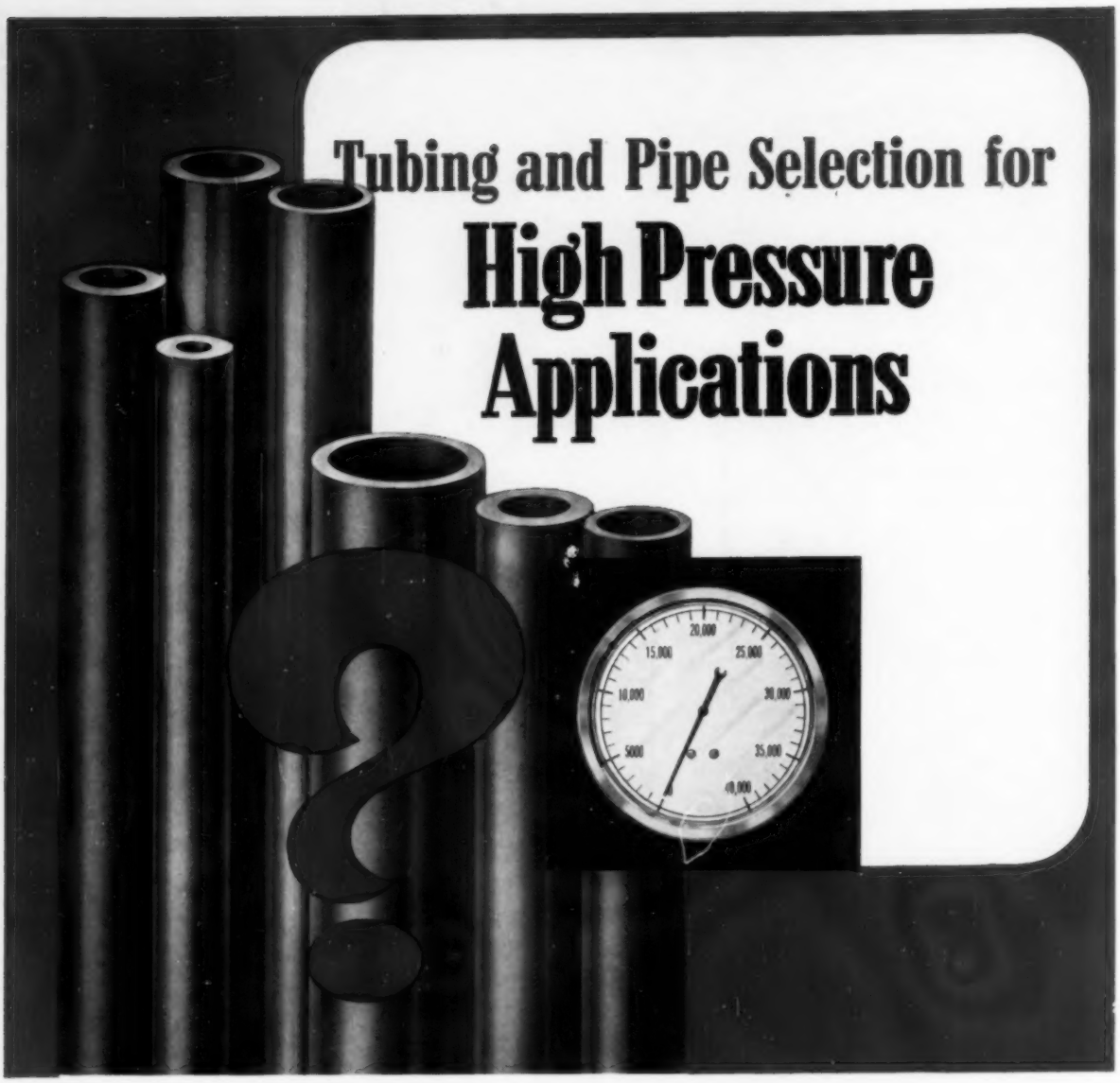

Specific working pressure is one of the major considerations in the choice of tubing or pipe for a given fluid-handling application. To obtain optimum efficiency and economy, however, it is necessary to consider temperature conditions, tube size, mechanical strength of the steel, and corrosion hazards.

A case in point that clearly shows the complexity of selecting the right tubing for pressure applications involved the installation of a stabilized stainless steel to carry methanol and unreacted synthesis gases at 300 F and 5000 psi while being exposed to chloride-bearing bayou water. This exposure caused pitting corrosion which, in turn, localized the pressure stresses at the roots of the pits causing, eventually, failure by stress corrosion. To effectively solve this costly problem, B&W with its long experience in all phases of tubing applications, helped in selection of B&W Croloy 5. This choice provided increased resistance to the pitting while meeting the temperature and pressure factors satisfactorily *and at a substantial savings in material cost.*

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TA-5058-P

Addition Agents for LUBRICANTS

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Part 1

Multimillion pounds of additives worth multimillion dollars are consumed by the refining industry annually in bettering lubricants for every purpose

C. J. Boner

Chief Research Chemist, Battenfeld Grease & Oil Corporation

A variety of chemical compounds or mixtures are added to various petroleum products, generally in small concentrations, for the purpose of improving some specific quality of composition. Such modifiers have been given the name additives. Webber[19] defines these materials as follows: "Additives are substances which impart or enhance the desirable properties of a lubricant and eliminate or minimize the deleterious ones." Such action need not be confined to lubricants, and it will be found that almost all liquid petroleum fuels and some solvents also include additives.

The class of additives may be designated by a descriptive name, as for example oxidation inhibitors, extreme pressure agents, etc. As the subject unfolds, it will be evident that a single modifier may often serve more than one purpose.

These additives increase both the value and usefulness of petroleum products. The tonnage and monetary value of the yearly consumption of the compounds being considered is of such magnitude that figures for the totals are of interest. Although the present article does not cover liquid fuels, the additive consumption for such purposes is of enough importance that this is included in the tabulations. Information by Beard,[2] no doubt collected for 1953, is given in Tables 1, 2, and 3. A similar summary by Larson[12] (Table 4) shows the expected consumption of similar compounds for 1955. The increase in volume and cost of additives used in a two-year period is quite evident.

Patents Applicable to Lubricant Additives

Georgi[7 p. 127] stated in 1950 that more than a 1000 U. S. patents had been granted in recent years on various additives and additive-oil compositions. No complete summary of patents dealing with additives has been published recently. Georgi[7] lists quite a number of patents as late as 1948. Boner[4] uses many patents, as late as 1952, as illustrations dealing with lubricating greases.

For those desiring to study patent listings before the last few years, the following articles may be of interest:

J. H. Byers:

"The Patent Structure of Pour Point Inhibitors," *National Petroleum News*, p 83-98, December 2, 1936.

"Organic Amines and Hydroxy Compounds," ibid, p 67-70 February 10, 1937.

"Oiliness Agents," ibid, p R3-8, July 14, 1937.

"Synthetic Lubricants (Additives)." ibid, p R218-226, October 6, 1937.

"Additives of Mineraloid Character," ibid. p R359-364, December 1, 1937.

TABLE 1. Estimated annual consumption of additives for gasoline.[a]

Additive	Approximate dosage	Million pounds	Million dollars
Tetraethyl lead	3 ml per gal (max)	350	225
Antioxidants	5 lb per 1000 bbl	5.5	6
Metal deactivators	1 lb per 1000 bbl	0.75	1.4
Antirust	10-50 ppm	—	
Anti-icing	1 per cent		
Pre-ignition preventers	A few tenths of 1 per cent	—	Several
Upper cylinder lubricant	A few tenths of 1 per cent	—	million
Dyes and decolorizers	A few parts per million	—	dollars

[a]Figures for tetraethyl lead are actual; others are estimated and represent in some cases only order of magnitude values. From *ASTM Bulletin*, May, 1954, p. 51

TABLE 2. Estimated potential annual consumption of additives for No. 2 fuel oil and diesel fuels.

Kind	Dosage	Million pounds	Million dollars
Fuel oil (antiscreen clogging and inhibitor of sediment formation)	20-50 lb per 1000 bbl	10[a]	3-5[a]
Diesel fuel (cetane number improvers)	A few tenths of 1 per cent	b	b

[a]Probably 50 per cent of potential.
[b]Development is too recent to attempt even an estimate. From *ASTM Bulletin*, May, 1954, p. 51

TABLE 3. Estimated annual consumption of additives for lubricating oil.

Kind	Dosage per cent	Million pounds	Million dollars
Detergents	2-10	250	50
Antioxidants—corrosion inhibitors	0.5-2	60	12
Extreme pressure agents	5-10	50	13
Viscosity index improvers	0.5-10	50	13
Pour point depressants	0.1-1	5	2
Defoamants	0.0001-0.001	—	—
Oiliness imparters	0.1-1	a	10
Antirust agents	0.1-1	—	—
Fluorescant dyes	a	—	—

[a]No estimate available. From *ASTM Bulletin*, May, 1954, p. 51

M. G. Van Voorhis:
"200 Lubricant Additive Patents Issued in 1938 and 1939," *National Petroleum News*, p 66-77, March 6, 1940.
W. A. Wright:
"A Survey of Past and Present Trends in Lubricating Oil Additives," SAE Meeting Tulsa, November 9, 1944.
George G. Pitzer:
"Sulfonic Derivatives as Lubricant Additives," *National Petroleum News*, 37, No. 40 p 793-800, October 3, 1945
"Sulfur and Sulfur Chloride Organic Reaction Products as Lube Oil Additives," ibid., No. 37, p. R871-882, November 7, 1945.
"Phosphorus Sulfide Organic Reaction Products as Lube Oil Additives," ibid., No. 49, P. R 1001-1010, December 5, 1945.
H. H. Zuidema:
"The Role of Dispersants in Lubricating Oils," *Oil Gas. J.* p 93-101, January 22, 1948.
Helen Sellei:
"Sulfurized Extreme-Pressure Lubricants and Cutting Oils, A Literature and Patent Survey," *Petroleum Processing*, September and October, 1949.
C. V. Smalheer and T. W. Mastin:
"Phosphorus in the Lubricants Field," *Petroleum Processing*, 7, p 1780-1784, December, 1952.

It will be found that only a fraction of the materials and compounds listed in patents covering lubricant additives have actually been employed commercially. Any proposed additive has to be practical from a cost and manufacturing standpoint in order to be considered for use in lubricants. After it satisfies these conditions, it must undergo very extensive tests before being adopted.

The major oil companies, who have large research staffs, generally have a number of technical people constantly at work on lubricant additives. While the primary purpose is to improve their own products, some such companies manufacture the additives they develop and offer these to compounders of lubricants. Also some of the larger chemical manufacturers, finding that certain of their organic chemicals will serve as oil modifiers, set up divisions that devote their efforts to developing, manufacturing, and marketing oil additives. One of the largest additive suppliers has made this its main endeavor although the company has cooperated with oil companies in the patent field.

While all of the above does not preclude the possibility of a small organization developing additives, the wiser policy for a small consumer of such compounds is perhaps to deal with one of the groups mentioned above. Such firms have not only had wide experience, but they also render considerable service and no doubt protection from patent infringement.

It does not seem that the status, visualized by Prutton[16] in 1941, has been reached although it may be approaching. This thought was: "It is probable that within the next few years, additives for film strength, friction reduction, corrosion and oxidation inhibition, and for detergency, will become fairly well standardized, probably with a dozen or so in each class."

How Additives Function

Additives may function either by chemical or by physical means. For example, pour depressant or V.I. improvers act by physical means, whereas oxidation inhibitors or E.P. agents are valuable because of chemical changes that they undergo.

Many additives will be found to have a dual or even a multi-function. Thus, some V.I. improvers will also reduce the pour point of certain oils.

The synergistic action of certain additives should not be overlooked. Synergism is defined as "cooperative action of discrete agencies such that the total effect is greater than the sum of the two effects taken independently." In such cases, not only can the total proportions of additives used be reduced but also improved effects often result. This action generally refers to

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the function of compounds designed for the same purpose, for example two different oxidation inhibitors may be used in one composition. A certain polymer, "Plexol 305," is stated to act as a synergist in the case of rust-preventive compounds.

A specific additive may not have the same value or activity in all types of lubricants. For example, an oxidation inhibitor that retards deterioration of a conventionally refined Mid-Continent lubricating oil may not do so well in either a solvent refined or a Coastal oil. For this reason, both bench and road tests are often necessary in order to determine the value of each specific oil-additive mixture.

TABLE 4. Estimated annual consumption of additives—1955.

Additive	Approximate dosage	Million pounds	Million dollars
For gasoline			
Tetraethyl lead	nil to 3 ml per gal.	400–450	250
Antioxidants	2-16 lb per 1000 bbl	6	7
Metal deactivators	1-3 lb per 1000 bbl	1.5	2
Corrosion inhibitors	10-50 ppm	5	1
Anti-icing	½ to 1 per cent	190	10
Preignition preventers	0.01–0.02 per cent	8	3
Upper cylinder lubricants	A few tenths of 1 per cent	140	5
Dyes and decolorizers	A few parts per million	1	1
For fuel oil and diesel fuels			
Fuel oil antiscreen clogging and inhibitors of sediment and gum formation, antirust and anti-corrosion	20-35 lb per 1000 bbl	12	4-6
Diesel fuel-octane Number improvers	0.1–0.3 per cent	1	0.3
For lubricants			
Detergents	2–10 per cent	280–300	57
Antioxidants-corrosion inhibitors	0.4–2 per cent	70–75	15
Viscosity index improvers	0.5–10 per cent	60–65	15
Pour point depressants	0.1–1 per cent	5	2
Extreme pressure agents	5–10 per cent	60	14
Defoamants	0.0002–0.07 per cent	—	—
Antirust agents	0.1–1 per cent	—	—
Odor control	0.001–0.005 per cent	—	6
Oiliness imparters	0.1–1 per cent	—	—
Fluorescent dyes	—	—	—

Compiled from article by C. M. Larson, *The Petroleum Engineer*, March, 1955.

Effect of Additives on Lubricant Characteristics

While the primary purpose of an additive is to modify some specific property of a lubricant, the influence on characteristics other than the one in question must be considered. Naturally, additives used in large concentrations will have the greatest effect on characteristics, and conversely small proportions may have little influence.

Agents that are dark colored, such as most detergents, will not only darken the oil or lubricating greases but may also influence the cast or outertone. Thus, the green bloom may be lost and a red, brown, or blue cast be contributed. Such a change in color will be most pronounced in the case of detergents or E.P. compounds, which are used in a proportion of several per cent.

Some additives, particularly E.P. compounds, may not have too pleasant an odor and this will be contributed to

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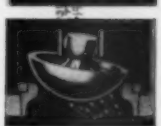

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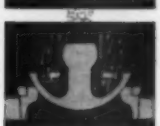

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the lubricant. Such odors will be accentuated by heat, and cases have been known where riders in an automobile could detect the odor of the lubricant in a transmission case. When a container of a lubricant containing some E.P. compounds is opened after storage, traces of hydrogen sulfide may be evident.

The ash of lubricants containing metal compounds as additives will be increased. Likewise, the carbon residue of a lubricating oil having a modifier present will often be raised.

Some lubricant additives have a low flash when compared to the untreated oil, but any lowering of this test due to the mixture is seldom of sufficient importance to condemn the oil.

The neutralization number of a lubricant is often changed when an additive is present. In fact, a change to either an increased basicity or acidity often will indicate the presence of an additive.

Frequently, lubricating oils containing additives will form emulsions more readily than will the initial oil.

Large proportions of additives may change the viscosity, V.I. or pour point of a lubricating oil although they were not used with this in mind. The API gravity of oils will often be decreased by the presence of modifiers, that is, the compounded lubricant will weigh more per gallon than the base stock.

All of the above points should have consideration before deciding upon an additive.

Types of Additives

In the following listing of types of additives, it will be found that the designation often indicates the function. This listing is not necessarily in the order of importance nor of cost but only in the order in which the types will be discussed.

It should be mentioned that certain components of some lubricating oils may function the same as additives. For example, Smackover oils often have sulfur compounds naturally occuring that serve as film-strength agents. Likewise, conventionally refined lubricating oils sometimes contain natural oxidation inhibitors that are lacking in solvent refined oils.

Impurities or products of reactions during processing should also be considered since they may act as either anti- or pro- bodies. Thus, in the case of petroleum sulfonates, which are valuable as rust-preventive additives, the presence of inorganic salts may lead to staining of copper. Glycerol, resulting from the saponification of fats, may remain in a lubricating grease and increase the susceptibility of the product to oxidation.

The Author

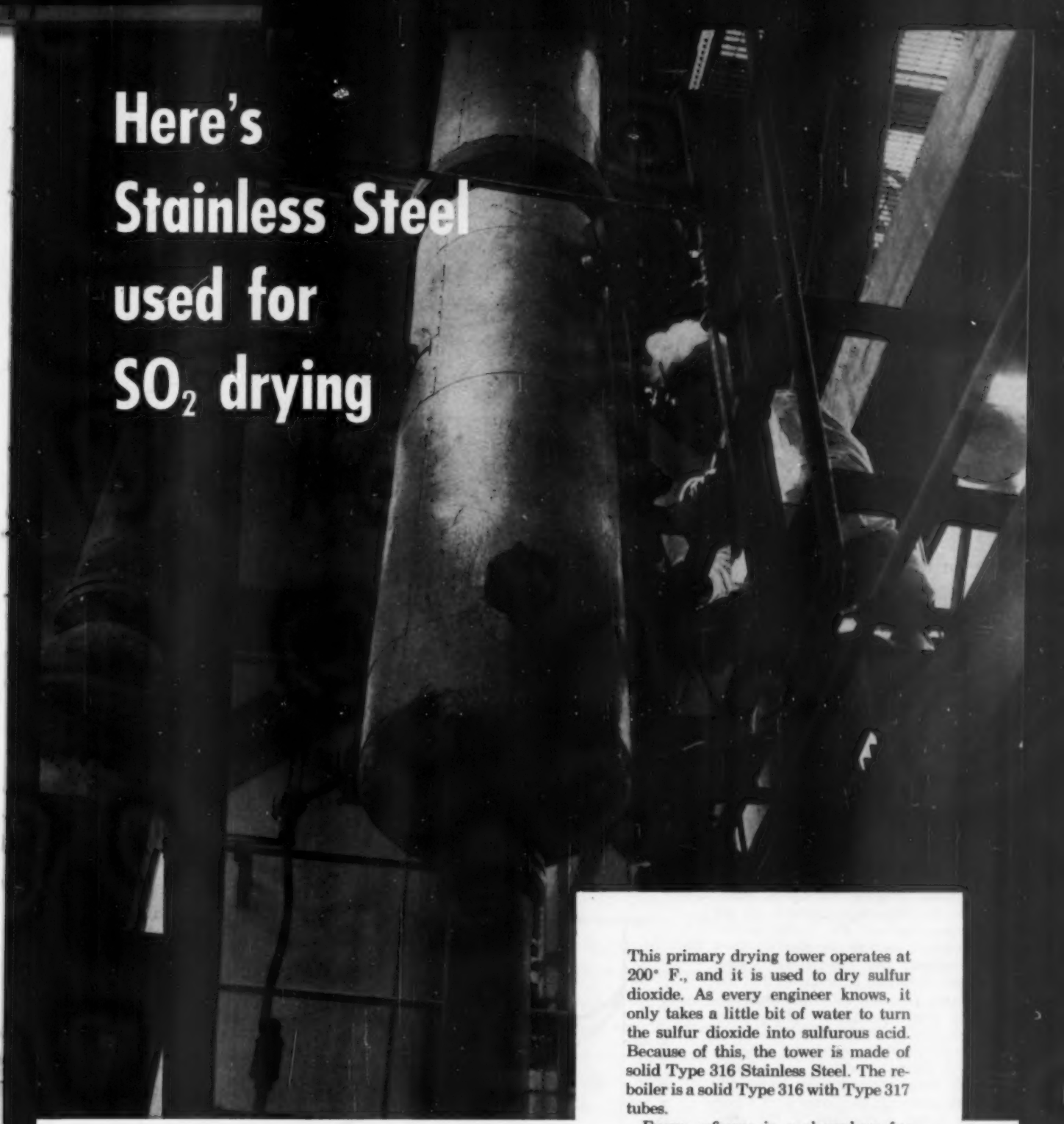
C. J. "Charley" Boner is too well known to his industry to need any further introduction. Author of many articles and the recently published monumental work *Manufacture and Application of Lubricating Greases*, he is one of the outstanding authorities in this field. His most recent honor was the award by the National Lubricating Grease Institute on November 1, 1955, in recognition of the most valuable contribution to the lubricating grease industry during the preceding year, as the author of this book.

1. Antioxidants or Oxidation Inhibitors
2. Corrosion Inhibitors
3. Metal Deactivators
4. Rust Inhibitors
5. Color Stabilizers
6. Detergents
7. V. I. Improvers
8. Pour Depressants
9. Oiliness Agents
10. Film-Strength Agents
11. Wear-Prevention Agents
12. Antifoam Agents
13. Emulsifiers
14. Water Repellants
15. Stringinesss Additives
16. Dyes
17. Odor Control Agents
18. Structure Modifiers for Soap-Oil Systems

Oxidation Inhibitors

Without entering into details, it has been found that the oxidation of most hydrocarbons, which includes lubricating oils, is a chain reaction. By this is meant that once oxidation is initiated, the products of the reaction will tend to promote further deterioration of the initial product. There are exceptions to this rule, and Larsen and Diamond[11] consider some compounds retardants. A retardant is a compound which upon oxidation is converted into an inhibitor. Larsen, Thorpe, and Armfield[10] illustrate this point by showing that naphthalene aromatics are more stable than their benzene homologs because naphthols formed by oxidation of the former are better oxidation inhibitors than the phenols formed from the latter.

Three possibilities for the disposition of the oxidation inhibitor after reaction have been suggested by Murphy *et al*[15]. These are: (a) The inhibitor is oxidized to a compound that is incapable of further antioxidant action; (b) the inhibitor is oxidized to a compound



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that exhibits antioxidant action, perhaps to a lesser degree, and that may upon still further oxidation become inactive; (c) the inhibitor is capable of regeneration.

Oxidation reaction can be accelerated by a catalyst, by intimate mixing of the reacting ingredients, or by increase in temperature.

The most potent catalysts normally encountered are metals or metal compounds, such as soaps of copper, iron, or lead. Metal deactivators, to be described later, may nullify the catalytic action of metals.

To retard oxidation, certain classes of compounds are added to lubricants. The ones most often used are inhibitors that are active in breaking chain reactions so that one molecule of inhibitor is capable of preventing the oxidation of many oil molecules.

The types of compounds that are most effective as oxidation inhibitors for lubricants include:

(a) Nitrogen compounds, such as amines
(b) Hydroxy compounds, such as phenols and naphthols
(c) Sulfur compounds, such as disulfides and thioethers
(d) Halogen compounds
(e) Compounds of phosphorus, arsenic, antimony, selenium, and tellurium.

No single oxidation inhibitor will serve for all lubricants or for all service conditions. Therefore, information will be given as to what specific oxidation inhibitors have been used for different lubricants.

Antioxidants for Lubricating Oils

It is desirable to combine inhibition against oxidation with protection from corrosion of alloy bearings in crankcase oils. Suitable compounds for the purpose include: Zinc dialkyl dithiophosphate, such as zinc dihexyl dithiophosphate; zinc dibutyl dithiocarbamate; sulfurized terpenes, such as sulfurized pine oil; sulfurized wax olefins; tributyl phosphite; triphenyl phosphite; sulfurized sperm oil; tetramethyl diaminodiphenylmethane; calcium cetyl phenate; lecithin; and alizarin. The latter compound in conjunction with other additives may yield a purple color, particularly if the other modifier is basic.

Since, according to Georgi,[7] p.for oxidation and corrosion inhibitors containing both phosphorus and sulfur are more effective in a wide variety of lubricating oil stocks than are compounds containing only one such element, the former are much used. Such inhibitors are often derived from the action of phosphorus pentasulfide on unsaturated organic compounds or on

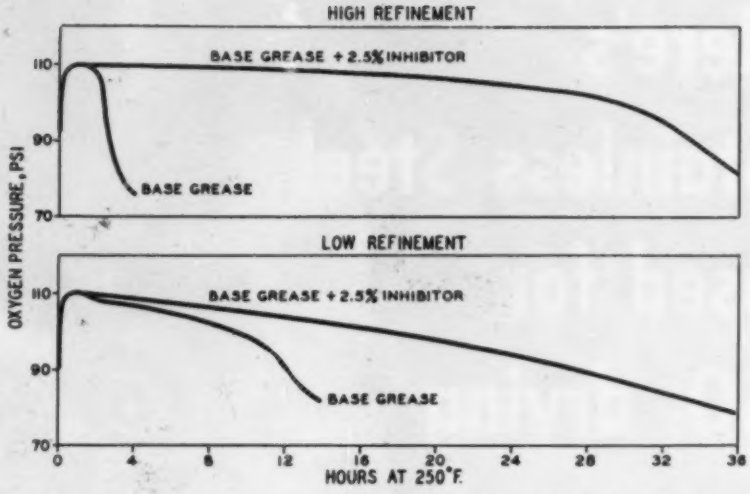

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FIG. 1. Inhibitor response as function of mineral oil refinement.

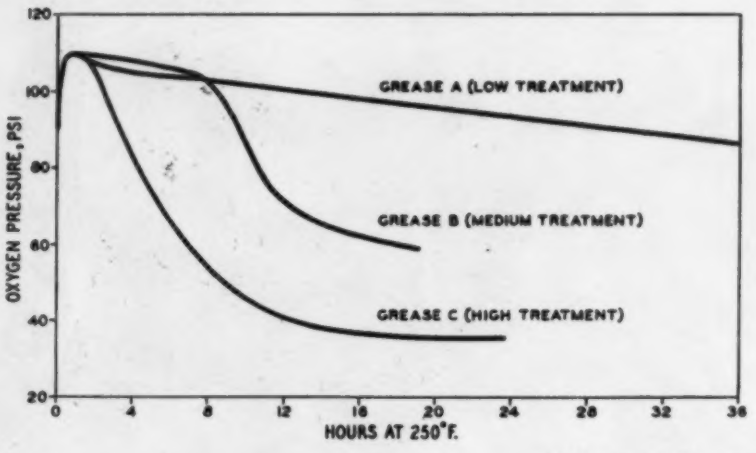

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FIG. 2. Effect of mineral oil treatment on oxygen absorption of sodium soap greases.

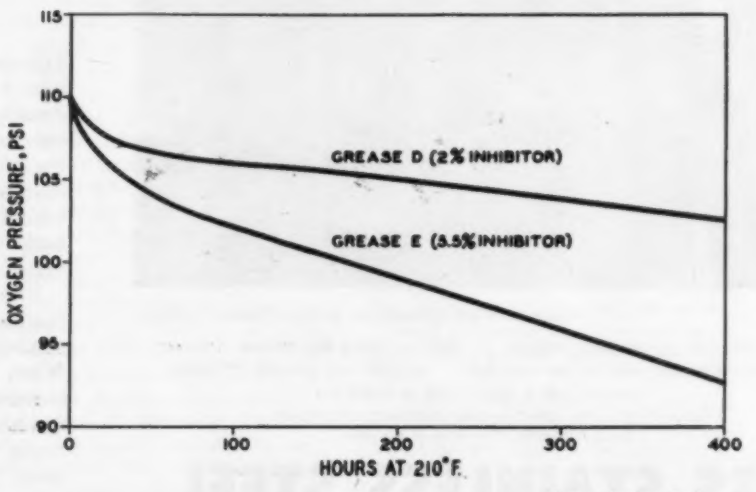

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FIG. 3. Inversion of effectiveness of oxidation inhibitor with varying concentrations.

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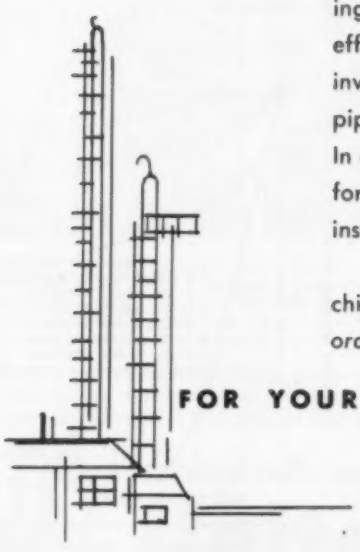

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high molecular-weight alcohols after which a metal salt is formed.

The above compounds in a proportion of 0.5 to 1 per cent may be the only additives present in some ML (light-duty) classification crankcase oils. The same proportion may also be included, along with other types of additives, in the classifications for heavier duty oils.

Often it is desirable to use what may be termed a primary inhibitor and a secondary one in the same oil composition. For example, Roberts[17] suggests a mixture of complex amines and a phosphorus pentasulfide-polybutene reaction product as an antioxidant and corrosion inhibitor in motor oils.

In the case of diesel oils, some of the compounds mentioned above may be included such as zinc dialkyl dithiophosphates. These particular oils are so heavily doped, however, that some of the other additives present may help retard oxidation.

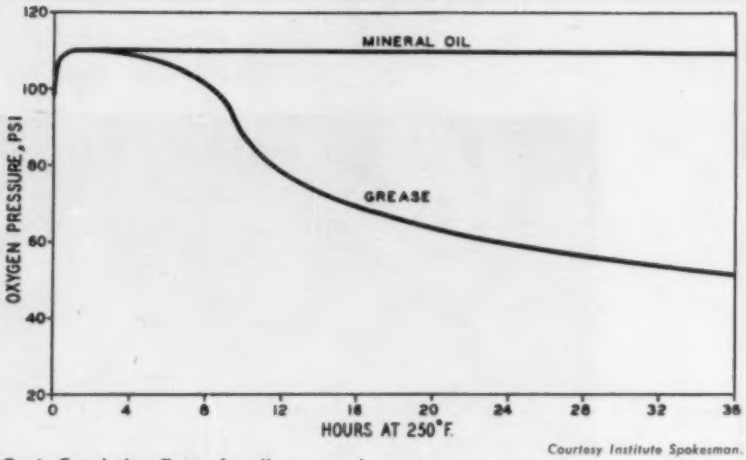
Antioxidants used in turbine and hydraulic oils may consist of 0.1 to 0.5 per cent of 2.6-ditertiary-butyl-4-methyl phenol, beta naphthol, or phenyl beta naphthylamine. The same additives will serve for lubricating oils used in circulating systems and in compressors unless the temperature of the oil exceeds 175 F. In this case, some of the inhibitors recommended for crankcase oils will be better.

Oils used for electric motors should have long life and, hence, should contain oxidation inhibitors similar to those used in crankcase oils. Spindle oils may or may not have similar antioxidants as do turbine oils. Phenyl beta naphthylamine has a tendency to turn red on exposure to light, and hence, might be undesirable.

Lubricating oils that are used up rapidly, that is, which are renewed frequently, such as engine oils and general-purpose machine oils, do not require oxidation inhibitors. The presence of such modifiers, however, is not a detriment. Therefore, in case a factory desires to restrict the number of types of oils stocked, only those containing oxidation inhibitors should be considered.

It seems reasonable that to be successful in inhibiting a lubricant one should choose as stable a lubricating fluid as possible. Thus modern transformer oils, selected and carefully refined, will not deteriorate in service for long periods although some such oils may not contain inhibitors. However, ditertbutyl-paracresol is said to be used in electrical insulating oils.

The above point is illustrated in the case of lubricating greases by Fig. 1, where MacDonald and Dreher[14] confirm their statement that "In general, the oxygen absorption rates of greases,



Courtesy Institute Spokesman.

FIG. 4. Catalytic effect of sodium soap in grease.

prepared from refined mineral oils from the same crude oil, are directly proportional to the degree of refinement of the oil." In spite of this, some solvent-treated oils are more difficult to inhibit than some conventionally refined oils. Fig. 2, where oils of different degrees of refinement were employed, indicates this point.

Perhaps the character of the oil will determine what specific oxidation inhibitors should be used. For example, phenyl alpha or phenyl beta naphthylamine are thought to be satisfactory for "poor oils" while a mixture of substituted diphenylamines is more effective in solvent-refined oils.

Attention should be called to the fact that there is an optimum concentration of an oxidation inhibitor for any lubricating system. That is, too large a proportion of such an additive may be as bad as too little. Fig. 3 illustrates this point in the case of a lubricating grease.

Antioxidants for Synthetic Lubricating Fluids

The types of synthetic lubricating oils commonly used are susceptible to oxidation in service and, hence, require the addition of inhibitors. This is recognized in the case of "Ucon" fluids (polyalkylene glycols and derivatives) and such fluids are frequently inhibited by the manufacturer. Either "Ucon" or diester lubricants require about the same types of oxidation inhibitors that are used for petroleum oils, but some specific recommendations can be cited.

One supplier of additives recommends 0.1 to 0.25 per cent of either polymerized trimethyl-dihydroquinoline (Agerite Resin D) or styrenated phenol ("Agerite Spar") to inhibit oxidation in "Ucon" fluids. Harle[9] found that polyoxyalkylene glycol lubricants could be inhibited against oxidation by the use of a mixture of either phenyl alpha naphthylamine or tert-butylcatechol with certain polymers containing sulfur. Bondi [5 p. 367] mentions that polyethers are only moderately susceptible to most antioxidants.

Atkins *et al*[1] added from 0.10 to 0.20 per cent of various amines or phenol derivatives to diester lubricants and found most of them effective. Murphy *et al*[15] found that phenothiazine, in concentrations of less than 0.5 per cent, was a satisfactory antioxidant for bis (2-ethylhexyl) sebacate, one of the diesters largely used as a lubricant.

Silicone fluids, used as lubricants, have a tendency to gel at high temperatures due to increased polymerization, and some of the antioxidants used for mineral oils detract from this effect. One such additive is 1 per cent of isopropoxy-diphenylamine.

The synthetic lubricating oils derived from olefins and used by the Germans during the last war were inhibited against oxidation by phenothiazine and its derivatives.

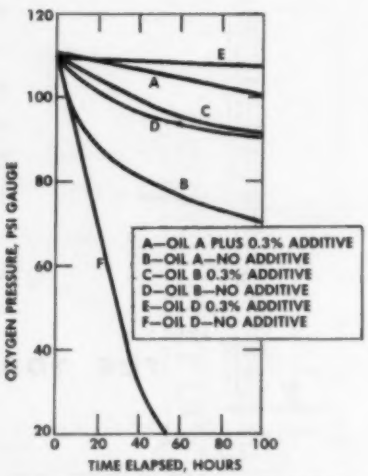


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FIG. 5. Response of various oil-bentone mixtures to oxidation inhibitor.

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Antioxidants for Lubricating Greases

While, as a whole, the same antioxidants that function in lubricating oils are also effective in lubricating greases, amine compounds give better results in the latter case than do substituted phenols. Quite a complete discussion of the use of such inhibitors is given by Boner.[4 p. 87-108] Calhoun[5] has recently presented the results of an investigation in which 69 different compounds or formulations were examined for their effectiveness as oxidation inhibitors in a variety of lubricating grease types and in several concentrations.

As with lubricating oils, accelerated oxidation tests are made on lubricating greases to determine if storage or service life will be satisfactory. The standard test for this purpose is ASTM Method D 942-50 in which a lubricating grease is subjected to an oxygen pressure of 110 lb for a period of 100 hr at 210 F. A loss in oxygen pressure of not over 5 psi in this period indicates that the lubricant is properly inhibited.

Specific oxidation inhibitors, all of which have been employed in lubricating greases in concentrations of 0.5 per cent or less, include phenyl alpha naphthylamine, "Ortholeum 300," "Agerite Stalite," and "Vanlube 26."

When investigating antioxidants for use in lubricating greases, the effect of the thickener should be considered. Most soaps have some catalytic effect on oxidation. For example, Fig. 4 indicates the effect of sodium soap when present in a mineral oil having satisfactory oxidation stability.

Not only are most oxidation inhibitors less effective in lubricants containing "Bentone" as a thickener, but also their presence decreases the thickening ability of the "Bentone." Even here presence of natural anti-oxidants or conversely of readily oxidized fractions may be of primary importance. This is evident by reference to Fig. 5, where one oil-"Bentone" mixture shows little improvement with the addition of an oxidation inhibitor while other mixtures show marked improvement.

Method of Addition of Antioxidants

Most compounds or mixtures suggested for use as oxidation inhibitors are soluble in mineral oils in the concentrations in which they will be used. For example, phenyl alpha naphthylamine is soluble to the extent of 2 per cent in most mineral oils at room temperature. Many such additives are crystalline or solid flakes or powders. If they are not liquids, the melting point may vary from 125 to 300 F.

As a matter of convenience, solutions of such antioxidants are often furnished. For example, di-tert-butyl-para-cresol is a white or pale yellow solid. Also a 33⅓ per cent solution in toluene is provided for pumping through proportioning devices into gasoline lines where it will act as a retardant toward gum formation. Also a 20 per cent solution of this compound in a high-quality transformer oil is furnished so that a 1.5 per cent addition of the liquid will be equivalent to 0.3 per cent of the solid.

In any event, thorough mixing of the antioxidant with the lubricant is necessary. If the entire lot of the lubricant is not to be warmed or if the inhibitor is to be added by means of proportioning equipment, it is best to make up a concentrate of the additive in oil and to use portions of this in blending. Other solubilizing agents may be required if the inhibitor has a low solubility in oil. Thus, Fraser and Maxwell[6] found that phenylenediamine was only soluble in a lubricant to the extent of 0.1 per cent. In order to use a higher concentration than this, alcohols, ethanol amines, or butyl carbitol were used as dispersing agents.

In lots of lubricating grease, it is best to add the anti-oxidant when the batch is about completed and at a temperature of 150 to 250 F. Higher temperatures may cause reactions or even decomposition of the additive. One supplier of such a compound "Ortholeum 300" gives the following caution about addition and mixing: "To prevent deterioration, the temperature should not be permitted to go above 300 F, even for a short period."

Cautions in the Use of Inhibitors

Many oxidation inhibitors may cause skin irritation upon prolonged contact. Handling such ingredients with shovels and also personal cleanliness should prevent trouble from this source.

Some antioxidants, such as phenyl alpha naphthylamine, will darken on exposure to light. Phenyl beta naphthylamine and "Ortholeum 300" discolor to a lesser extent.

Such discoloration may not only change the color of the lubricant but may even contribute undesirable color to objects with which it comes in contact. One such case was that of a manufacturer of household appliances that had a white finish. Yellowing of this enamel was noted in places, and this was traced to the lubricant, which had leaked on the surface. The actual offender was no doubt an additive present in the lubricant and very likely an organic amine present as an oxidation inhibitor.

TABLE 5. Suggested oxidation inhibitors.

Trade name of antioxidant	Supplier	Cost per lb approximate	Chemical description
Calco Inhibitor MB	American Cyanamid Co.	.63	tetramethyldiamino-diphenyl-methane
—	Dow Chemical Co.	.34	diphenylamine
Ortholeum 300	E. I. duPont de Nemours & Co.	.77	mixture of amines
Neozone A	E. I. DuPont de Nemours & Co.	.58	phenyl alpha naphthylamine
Tenamene II	Eastman Chemical Products	—	phenylenediamines
Paranox 441	Enjay Co.	—	trialkyl phenol
—	Koppers Co.	—	di-tert-butyl-para-cresol
Santolube 31	Monsanto Chemical Co.	.79	phosphite ester of alkylated phenol
Additive 250	Oronite Chemical Co.	$4.04	organic selenide compound
Anti-Oxidant 77-0	Sharples Chemicals, Inc.	—	zinc dibutyl dithiocarbamate
Ionol	Shell Chemical Co.	.95	tri-substituted phenol
Agerite Hipar	R. T. Vanderbilt Co.	—	mixture of amines
Agerite Powder	R. T. Vanderbilt Co.	.54	phenyl beta naphthylamine
Agerite Resin D	R. T. Vanderbilt Co.	—	polymerized trimethyl
Agerite Stalite	R. T. Vanderbilt Co.	—	dihydroquinoline
Agerite Stalite	R. T. Vanderbilt Co.	—	mixture of octylated and styrenated diphenylamines
Vanlube 26	R. T. Vanderbilt Co.	.62	mixture of substituted diphenylamines and zinc dithiocarbamate

Sources and Costs of Oxidation Inhibitors

Almost any supplier of additives for lubricants can suggest and furnish antioxidants. Often these are sold under a trade name that may not reveal the composition. Most of these suppliers, however, will advise the general nature of the compound or mixture so that the user need not be in the dark as to what is being used. The listing in Table 5 is not complete but does give an idea of the variety and source of some antioxidants.

Corrosion Inhibitors for Lubricating Oils

The term corrosion inhibitors can have different meanings depending upon the system that is to be inhibited. In the present sense, we are concerned with additives that will retard or prevent corrosion of the various metals used in both automobile and diesel engines, particularly bearing metals.

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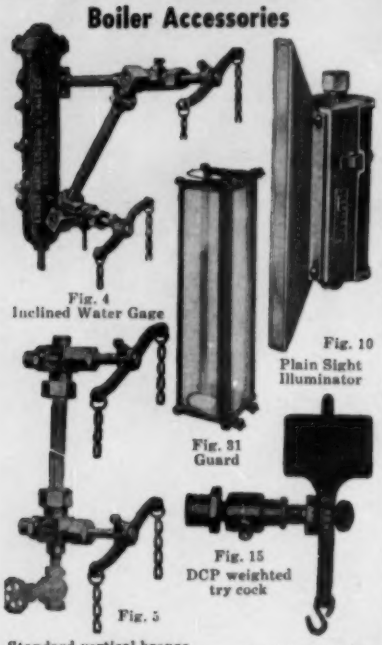

Fig. 4 Inclined Water Gage

Fig. 10 Plain Sight Illuminator

Fig. 31 Guard

Fig. 15 DCP weighted try cock

Fig. 5 Standard vertical bronze water gage, 350 pound

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of the lubricating fluid. Hence, any additive that will retard oxidation will in turn reduce bearing corrosion and, therefore, serve a dual purpose. Further, the inhibitors may function in two different manners. First, protective films or corrosion-resistant coatings may be formed on the bearings. Next, the action may be by retarding the formation of corrosive compounds, such as acids. The first type of inhibitor is generally an organic compound containing phosphorus and sulfur. The latter compounds are more often amines, which may actually neutralize some acids as well as break a chain reaction.

The corrosion inhibitors most widely used in lubricating oils are probably those containing both phosphorus and sulfur, as they seem more effective than compounds containing only one of these elements. Examples are zinc dihexyldithiophosphate and zinc cyclohexyl dithiophosphate. From 0.2 to 3 per cent of such compounds are added to oils. Phosphorus pentasulfide reaction products of unsaturated compounds are also of value as corrosion inhibitors. These may be derived from materials such as sperm oil, terpenes, polybutenes, etc. The value of such additives is evident in Fig. 7. In this illustration, the bearing on the left, after being run in a Chevrolet L-4 test, failed, as it lost perhaps 600-700 mg (maximum allowable 150 mg). The bearing on the right after a similar test was satisfactory.

Suppliers of additives often market inhibitor-detergent combinations some of which will be mentioned later.

Metal Deactivators

Certain metals, if acted upon by the oxidation products of lubricants, go into solution in the oils in the form of soaps. In this state, the metal compounds act as catalysts and accelerate the decomposition of the oil. Further, if the action on the metal is prolonged, the surface is etched, pitted, or even destroyed. One metal in particular that is prone to be attacked and that can be either deactivated or passified is copper or its alloys such as bronze.

Deactivators may act by either precipitating dissolved metal ions out of the oil or by forming inactive complexes with the metal compounds. In the case of passivators, an inactive film is formed on the surface of the metal. Zuidema[20 p. 96] mentions that in the case of copper-lead bearings a dark-colored film can be detected when certain sulfur compounds are employed as oil additives. Such film formation, however, seems to differ only in degree from actual corrosion when the sulfide particles become thick enough to flake off. The above subjects are covered in

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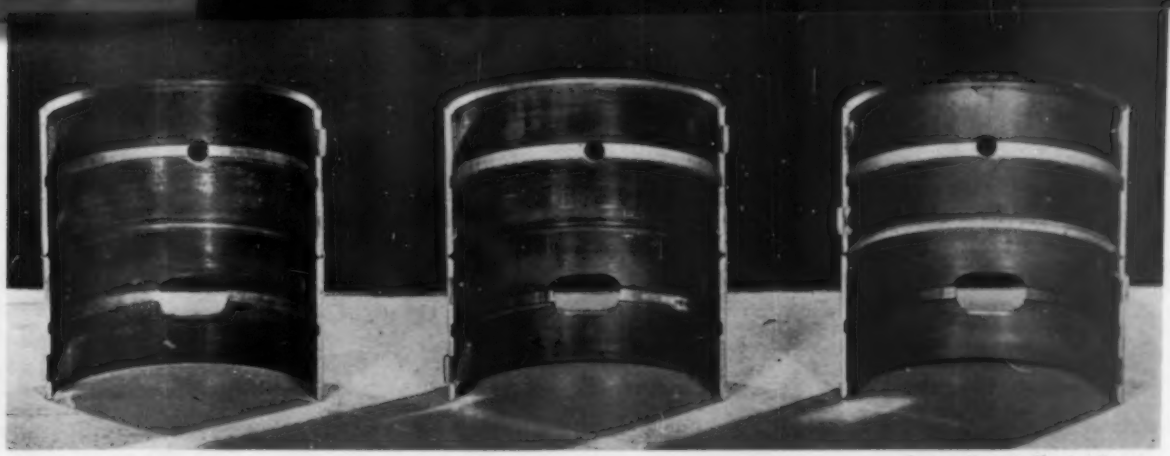


Courtesy Monsanto Chemical Company.

FIG. 6. Copper-lead bearings from Chevrolet L-4 test. Bearing on right shows effect of proper corrosion inhibitor.

greater detail by Boner.[4] p. 108-110

While a number of chemical compounds have been recommended for the above purposes, only some, which are readily available, will be mentioned. Mercaptobenzothiazole or zinc dibutyl-dithio-carbamate, in concentrations of 0.05 to 0.2 per cent should suffice for most lubricants. The latter compound also functions as an oxidation inhibitor, and if this is the purpose, a somewhat larger proportion may be used. Since an antioxidant is desirable in most lubricants in which metal deactivators are used, some suppliers of additives offer mixtures that will serve a dual purpose. In this case, the metal deactivator may be present in a proportion of 10 to 12 per cent of the additive. Such dual-purpose additives include "Ortholeum 300" marketed by DuPont or "Vanlube 26" sold by Vanderbilt.

In gasoline, N-N'-disalicylidene-1-2-diainopropane is said to be especially effective as a copper deactivator. "Tenamene 60" (Schiff base), distributed by Tennessee Eastman Company, is also said to be effective.

Rust Inhibitors

Rusting of ferrous metals that are in contact with lubricants can be due either to some component formed by the lubricant or to a contaminant, most often water. The latter fluid may also contain impurities, such as salt, which aggravates the rusting. Certain polar, surface-active compounds that tend to coat ferrous metals with a water-repellent film are effective rust-preventives, as can be seen from the results shown in Fig. 6.

Metal sulfonates, such as barium, calcium, or sodium sulfonates in a concentration of 0.1 to 2.0 per cent are frequently used as rust inhibitors. In some cases, such as in gasoline, ammonium sulfonate is used. The sulfonic acids from which these compounds are made may be of petroleum or synthetic origin and have molecular weights of 300 to 500. The final composition may be either neutral or basic. Metal sulfonates are quite viscous and, therefore, are most often supplied as solutions. Perhaps the most common form in which these compounds are marketed is as a 50 per cent solution in a refined, light colored oil. Such a solution may contain 0.2 to 2.0 per cent of water. It should be kept in mind that detergents added to lubricating oils are frequently sulfonates and, hence, such additives will also function as rust preventives.

Certain esters are also effective rust inhibitors when added to lubricants. For example, sorbitan monooleate or butyl stearate are sometimes used. Another sorbitan mono fatty acid ester ("Atpet 100" made by Atlas Powder Company) is said to be an improvement on the monooleate and in turbine oils is effective at concentrations as low as 0.001 to 0.04 per cent.

Allied to the esters because of their ester content are degras and oxidized petroleum fractions, such as "Alox 600," which have some use as rust preventatives. Since concentrations of 3 to 10 per cent of either of the above are required, their use is largely in either protective oils or slushing compounds. A "Bentone"-base lubricating grease is said to be inhibited against rusting if 3 to 4 per cent of an "Alox" compound is included in the mixture.

Courtesy Battenfeld Grease & Oil Corporation.

FIG. 7. Effect of inhibitor addition to lubricating grease subjected to salt spray for 100 hr. Upper panel inhibited, lower uninhibited.

Fatty amines, such as those produced from tallow fatty acids, have been used as rust preventives in lubricants. Some such compounds are corrosive enough to be harmful to the skin. Perhaps it was such an additive that led to the softening of paint films and caused the U. S. Government to include the following in specification MIL-G-16908 (Am. 1) where the following requirement appears: "The use of ingredients such as will stain the human skin in a semi-permanent manner or soften dried coatings of zinc chromate primer and synthetic lacquer-resistant primer is undesirable and may be cause for rejection of the material."

Phosphoric acid esters have been proposed as rust preventives in lubricants as have some long-chain fatty acids.

What are probably polymers distributed by Rohm and Haas under the names of "Plexol 305" and "Plexol 410" have been suggested as synergistic agents when used in conjunction with rust inhibitors in lubricants.

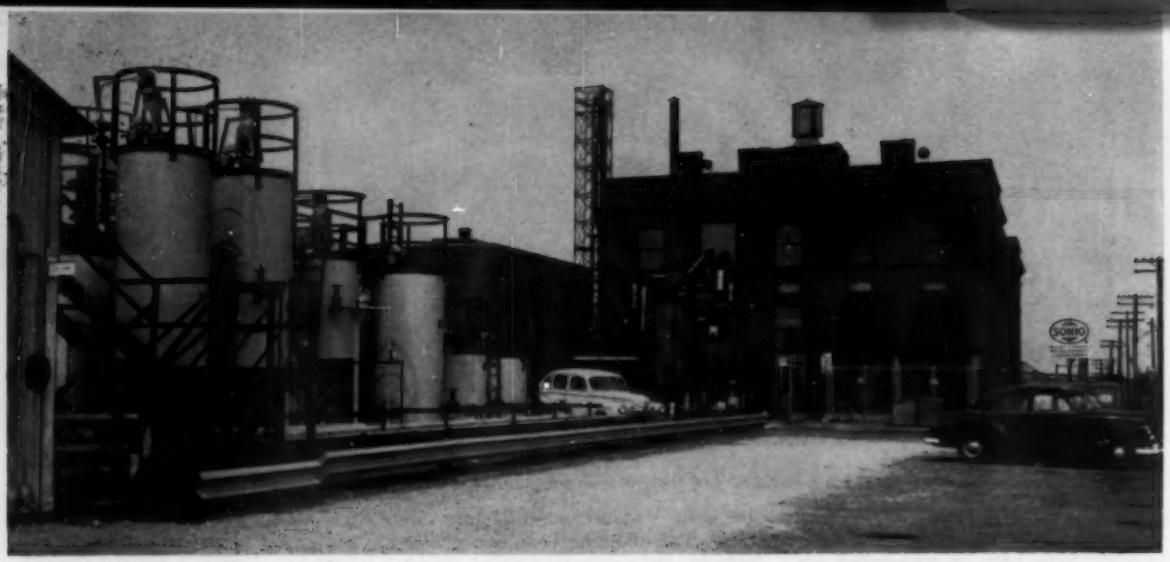
Color Stabilizers for Lubricants

While it might be desirable to stabilize the color for lubricants, additives are not normally used for this purpose. The darkening of mineral oils with the application of heat may be due either to oxidation products or to metallic salts that have gone into solution.

Zinc dibutyldithiocarbamate, in a concentration of 0.1 to 0.5 per cent should help stabilize color of lubricants. Hydroquin-one or substituted hydroquinones have been used to destroy color-forming bodies in kerosine and hence might be of value in lubricants.

The action of light may be different from that of heat in darkening lubricants, but the addition of 0.01 per cent of furfural azine is said to retard color deterioration of lubricating fractions, even when exposed to direct sunlight.

Part two to follow in early issue.

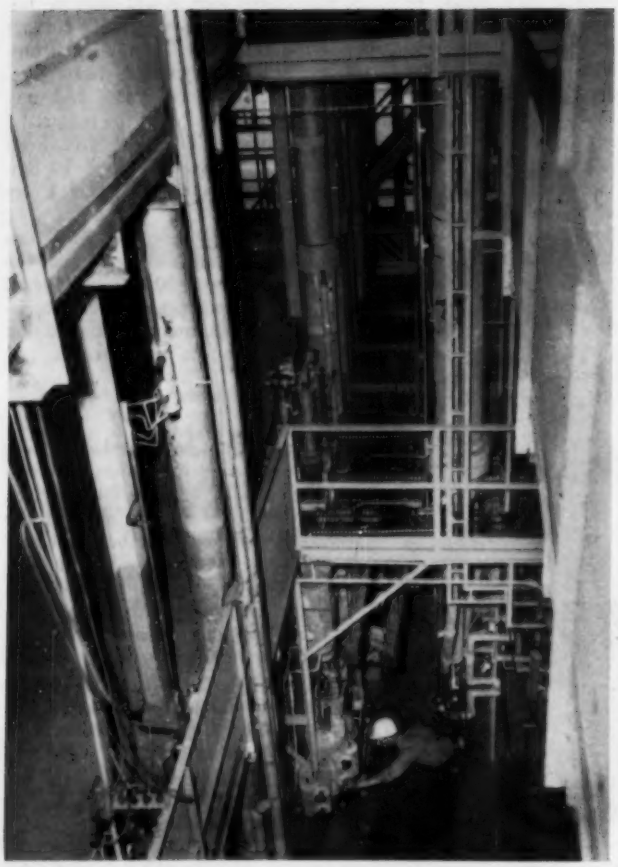


Miniature Tank Farm, stores gas-oil from Lima refinery, used for experimental processing in the small unit.

P 721.33

"Tom Thumb" Guides Operations

Results Obtained in One-Barrel-per-day Pilot Unit Directs Control of Huge Fluid Cat Cracker



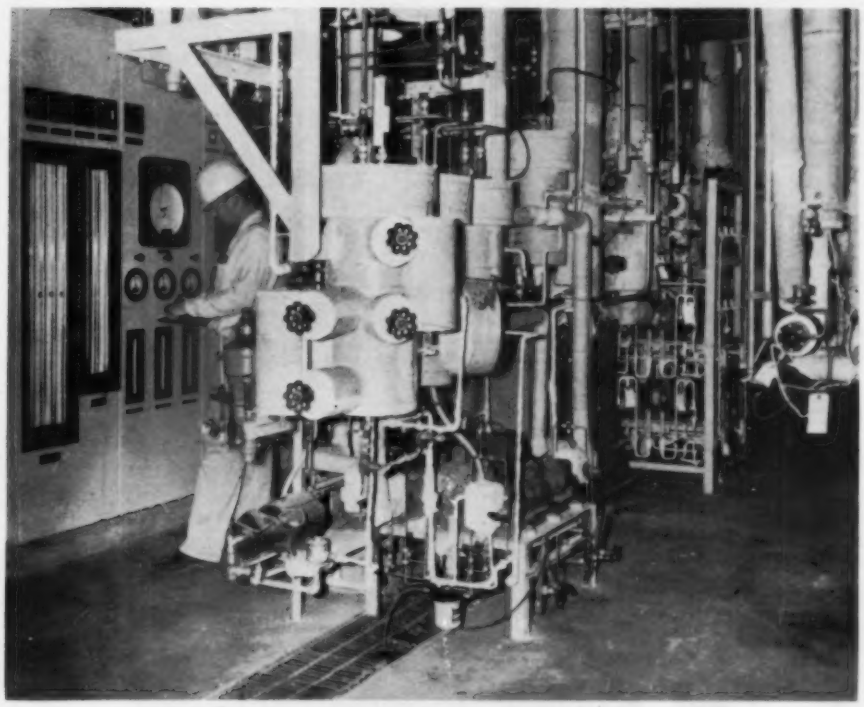
The Whole Unit from the third floor level. Operator is checking "synthetic crude" receiver; right-hand tower is reactor, three in center background are fractionators.

WHEN Standard Oil Company of Ohio's (SOHIO) newest catalytic cracking unit went on stream last summer, Sohio officials weren't holding their breaths in anticipation of new production records. In fact, just the opposite was true as the new unit would be lucky to squeeze out more than one barrel per day of refined product.

But this didn't come as a surprise to anyone at Sohio for they had planned and designed the new cat cracking unit in "Tom Thumb" proportions for just such a capacity. Actually, the new unit was designed and built by Sohio's process and product development personnel at their Cleveland, Ohio laboratory to simulate operation of Sohio's Lima, Ohio cat cracker on a scale that would permit

EXCLUSIVE

The Feed Stock (gas oil) is measured on these scales as first step in processing.



Instrumentation Board indicates the careful control that must be exercised to obtain satisfactory results from such small-scale operations. Most of the small piping is insulated individually.

extensive experimentation and analysis for improved production.

Ever since the Lima unit went in operation, Sohio refinery engineers have been concerned over the impracticality of experimenting with a full scale refining unit to adjust refining process variables for optimum production from various gas-oil feed stocks. With a 33,000 bbl per day throughput they found the continual operation required by production demands didn't permit the necessary freedom to perform such experimentation. Also in some instances such experimentation could prove to be costly due to the possibility of shut downs from operational upsets. Yet they felt that quality could be substantially improved by an adjustment of temperature, space velocity, pressure, catalyst to oil ratio or recycle ratio according to the particular feed stock being used.

An ideal practice would be to run a batch of feed stock through the refinery, altering variables to determine the best operating conditions for the feed stock being processed. With the "Tom Thumb" unit they can do just that, under actual refinery conditions and on a small scale, down-to-earth, practical basis. Initial operation of the unit for their study of feed stocks has already revealed some new facts and information.

The miniature refinery unit is for all practical purposes a copy of the cat cracking unit at Lima. Some modifications were naturally made due to size or equipment limitations. Catalytic cracking of petroleum is accomplished with a silica-alumina catalyst in a circulating solids system. The "Tom Thumb" pilot plant is a complete operating unit including extensive instrumentation and a miniature tank farm. Samples of the various gas-oil feed stocks to be processed at Lima are stored in a model tank farm and then piped over to the pilot plant for processing.

Perhaps one of the greatest problems confronting Sohio's process and product development people in designing a full scale refinery in miniature was the practicality of materials and equipment on this reduced scale. If they designed on too small a scale, pipe and tubing would be unable to handle the liquids in process, or operating equipment was unobtainable; if too large, the whole project would get out of hand. The final design was the result of a lot of study and planning that more or less hits the middle of the road as for size and does everything they had hoped for.

Once the design and engineering details were worked out to their satisfaction, Sohio process and product lab-

oratory decided to utilize an outside service for the specialized fabrication of all process equipment and erection of the entire pilot plant. Dravo Corporation, Pittsburgh, acted as prime contractor-fabricator and worked closely with Sohio in the development of the unit to the exacting tolerances required of such minute size.

All of the process equipment proper was fabricated from schedule 40 stainless steel with carbon steel being utilized for components. Pre-fabrication was done at Dravo's Marietta, Ohio plant so that the materials could be handled with specialized shop welding equipment and controlled techniques to meet some of the more exacting requirements of stainless.

A new technique was employed in the welding phases that eliminated the use of the conventional backing ring. With this technique a full, uniform penetration of weld was achieved without overhangs, icicles or crevices that could cause turbulence in flow and affect process results. All shop fabricated materials were inspected with special radioactive testing equipment that is capable of detecting flaws in welds up to four inches wide.

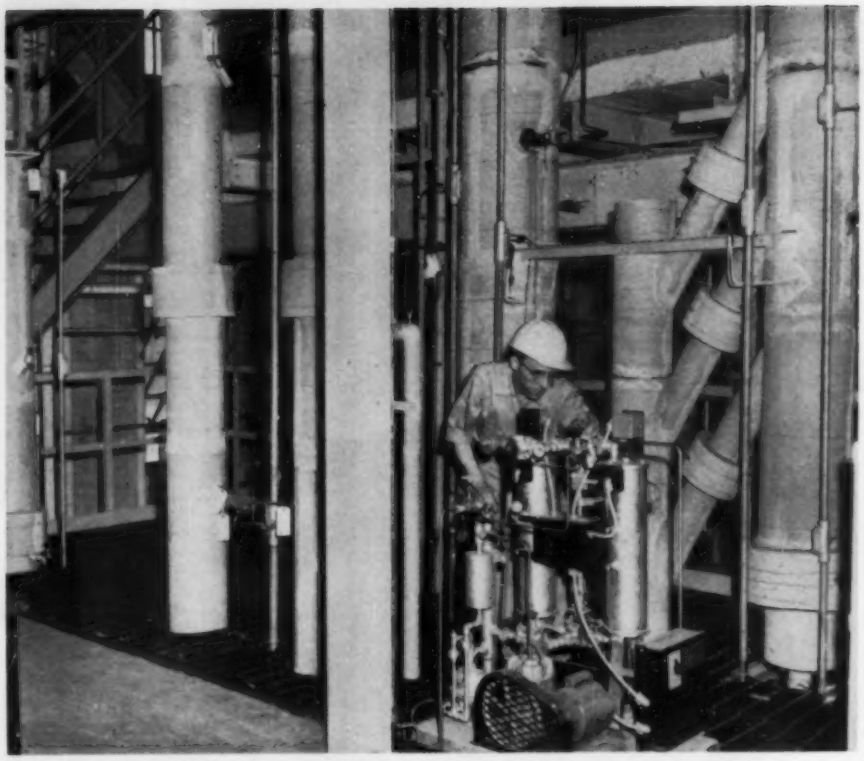
The gas-oil charge stock is brought in from Lima and stored in a model tank farm to be withdrawn according to test requirements. After leaving the tank farm, the feed stock is first weighed then piped to the charge preheater, then into the reactor section where the gas-oil feed breaks down into smaller molecules for further processing. From the reactor, the vapors are cycled through a condenser, separator, and on to the fractionating towers.

The spent catalyst flows through a steam stripper, then into the catalyst regenerator where it is reactivated.

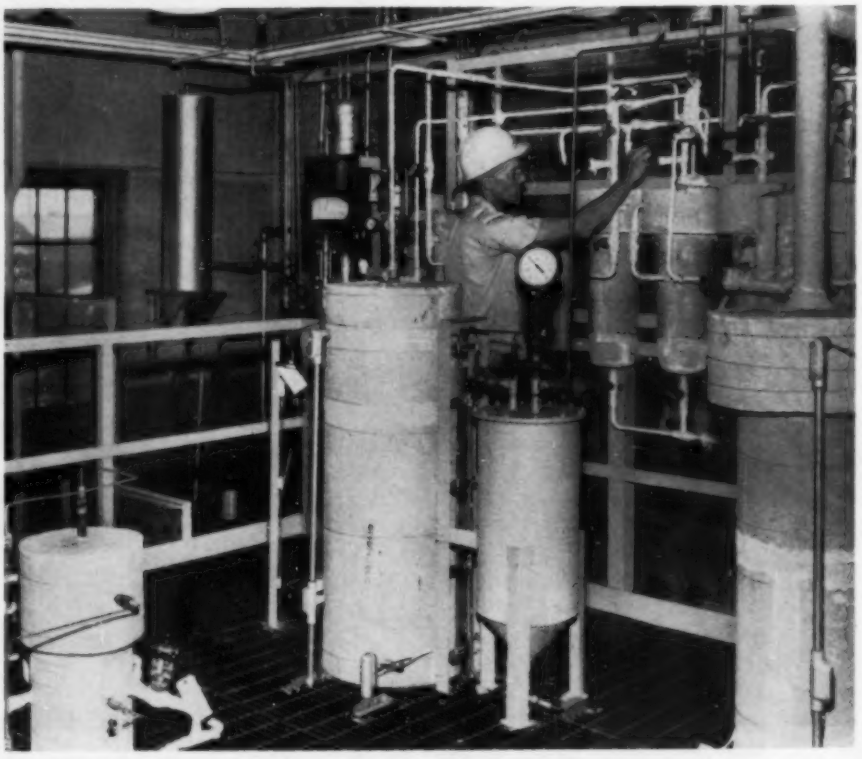
After the petroleum hydrocarbons leave the separator, they are preheated as necessary and processed through the three stainless steel fractionating towers: The first tower produces butane or propane; the second, gasoline; the third, light and heavy gas-oils, part of which may be recycled as required.

Control of the pilot plant is completely automatic through the use of standard process instrumentation. The maze of tubing proved to be a real plumber's nightmare in the actual tying in of the process lines with equipment and instrumentation on such a small scale.

Initial operation has been on a one barrel per day basis. Although it is too early to determine an accurate payout, Sohio feels that the unit will prove to be a very important tool in improving cat cracking operations. ★ ★ ★



Reactor, Stripper, Regenerator, from right to left shown in this view, with three gas fractionators; in foreground an electric dryer removes water from gas.



Top Level of the pilot unit, with reactor at right, then catalyst supply hopper, regenerator, and the top of the fractionator at extreme left foreground.

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TECHNOLOGY

Refining of Lubricating Oils

CHAPTER X.

Section II; Dewaxing; Selective Solvent Extraction

Dewaxing solvents have solved largely wax removal problem; selective solvents have raised stability, efficiency level of oils

V. A. Kalichevsky
Consulting chemical engineer

OLD dewaxing methods differed in their usefulness depending on the type of wax present in the oil. Two types of waxes are known to the refiner — paraffin wax and petrolatum.

Paraffin wax has a crystalline structure and is associated with the light distillates. Petrolatum, sometimes referred to as microcrystalline or amorphous wax, has a microcrystalline structure and is associated with the residuum. For separating these waxes, viscous oils were diluted with naphtha to make them fluid at low temperatures. The mixture was chilled, often 40 F to 50 F below the desired pour point of the oil, and wax removed.

Differences in the structure of the two types of waxes required the use of different methods for their separation from the oil. Paraffin wax was removed by filtering. Microcrystalline wax was removed by centrifuging. These methods were not interchangeable because paraffin wax could not be centrifuged and microcrystalline wax could not be filtered. These characteristics of the two waxes created many inconveniences to the refiner besides the necessity of having different plants for handling the waxy oils.

In preparing the lubricating-oil fractions, the refiner was forced to distill the crude oil not according to the viscosity of the products but for obtaining separation between the two types of waxes. Sharp separation could not be obtained, and an intermediate "slop cut" was collected. This cut contained both types of waxes and could not be filtered or centrifuged. It was discarded into the fuel oil. Present dewaxing methods were developed for overcoming these costly inconveniences and for increasing the yield of valuable products.

The very low-viscosity, lubricating-oil distillates are still dewaxed by the old method because they are easy to handle. These distillates are fluid at low temperatures and can be filtered without diluting them with solvents. The stock is chilled and passed through the filter presses, which retain the wax. This wax is called slack wax because it contains oil that must be removed if the wax is marketed. Pour point of the filtered oil is the same or very close to the chilling temperature. This happens because no naphtha is employed. If oils are diluted with naphtha, appreciable quantities of wax are retained in naphtha solution. When naphtha is distilled, this wax is left in the oil and raises the pour point of the product. Low chilling temperatures are needed to offset these solubility effects on the pour point of the oil.

Modern dewaxing methods are particularly advantageous when they are applied to viscous oils. The new solvents influence the size and shape of wax crystals formed on chilling and are in this respect superior to naphtha. These solvents are expensive, but their losses in processing are reduced to a negligible quantity by using vapor-tight equipment. Some solvents require filters, others need centrifuges for separating the wax, but distillate and residual stocks as well as the slop cut can be handled by these processes.

Solvent Dewaxing Processes

Dewaxing processes using filters are the Propane Process, the Benzol-Ketone Process and the Methyl-Butyl-Ketone Process. Those using centrifuges are the Bari-Sol and Separator-Nobel Dewaxing processes.

In the Propane Process, the oil is diluted with two to three volumes of propane and the mixture is chilled by auto-refrigeration, that is, by evaporating some of the propane under reduced pressure from the oil propane solution. The temperature differential, i.e., the difference between the chilling temperature and the pour point of the dewaxed oil, is 25-35 F, which is less than in naphtha dewaxing. Rate of chilling can be as high as several degrees Fahrenheit per minute while with naphtha it cannot exceed a few degrees per hour. The oil-propane solution is freed from the separated wax by filtering. The process is used mostly for dewaxing residual stocks.

In the Benzol-Ketone Process, also known as Benzol-Acetone Process, a mixture of solvents is employed. Benzol is an excellent solvent for the oil, but it dissolves appreciable quantities of wax. The separated wax is difficult to filter if only benzol is employed. Acetone is a poor solvent for oil and wax, but wax separates from it in excellently defined crystals. When mixtures of solvents are used in dewaxing, solvents like acetone are called "anti-solvents." Mixtures of benzol and acetone can be adjusted so as to have a satisfactory solvent power for the oil and to obtain a filterable wax. Instead of benzol, another hydrocarbon, toluol, is often used because of its low melting point.

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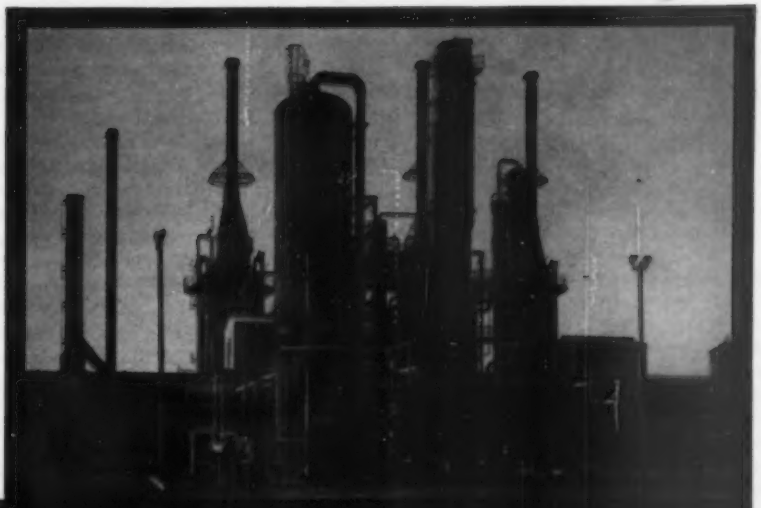

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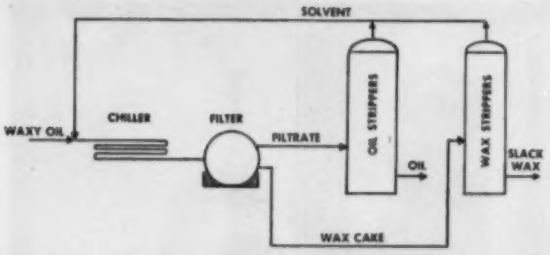

FIG. 5. The Benzol-Ketone Process for solvent dewaxing.

Benzol melts at +41.9 F and toluol at —139.2 F. Likewise, methyl-ethyl-ketone (MEK) is used instead of acetone because its boiling point (175.3 F) is higher than that of acetone (133.0 F), and the evaporation losses are, therefore, lower. Mixtures of toluol and MEK have better solubility characteristics toward the oil than the mixtures of benzol and acetone.

Flowsheet of the Benzol-Ketone Process is shown in Fig. 5. The waxy oil is diluted with the mixture of solvents and cooled by passing it through heat exchangers containing liquid ammonia. Instead of ammonia, liquid propane and other refrigerants can be used. The cold oil-solvent mixture containing wax in suspension is passed to the filters shown in Fig. 6. These filters are of continuous type, similar to those used in the Propane Dewaxing or in the Clay Contact processes but modified according to the service requirements. The filters used in the Benzol-Ketone Process are constructed and operated as follows:

Filters are rotating drums 10 ft in diameter and 16 to 20 ft long, but these dimensions are not critical. The drums are covered with filtering cloth, i.e., canvas. The drums are divided longitudinally into 30 sections. Each section works independently and is separated by blank walls from other sections. Piping is provided that permits application of vacuum or pressure to each section at will. This is done automatically.

The filter drum is partially immersed into a trough that contains the oil-solvent-wax slurry to be freed from the wax crystals. This whole system is enclosed in an air-tight stationary cover to prevent losses of solvent to the air and avoid the fire hazard. Suction is applied to the sections of the drum that are immersed. The oil-solvent mixture is soaked in, and wax deposits on the canvas. The mixture is transferred to the distillation equipment where the solvent is separated from the oil.

As the drum rotates, the submerged sections rise from the liquid. The wax cake deposited on the canvas is sprayed with chilled fresh solvent to remove the entrained oil. The wash solvent that passes through the canvas is used for diluting a fresh batch of waxy oil.

When the section occupies the top position on the rotating drum, it is no longer reached by the solvent spray but suction is continued to dry the wax cake. Suction stops when the section approaches the middle of the drum. Instead, suction pressure created by flue gases is applied to loosen the wax cake. Then all the valves are closed and wax is scraped off the canvas by the blade. This completes the cycle.

Alternate opening and closing of the valves is done in an ingenious way. A small stationary drum is located in the center of the rotating drum. The stationary drum is equipped with the pipe outlets through which vacuum or pressure is transmitted. Each section of the rotating drum has a connection that fits the successive outlets of the stationary drum as the drum rotates. Through these connections, vacuum or pressure is applied to the various sections of the rotating drum.

Wax removed from the canvas contains some solvent. This solvent is removed by distillation and wax sent to storage.

In the Methyl-Butyl-Ketone Process, a mixture of two solvents is also employed. One of these solvents is normal-propyl ketone, the other methyl-butyl ketone. Wax is separated by filtering.

In the centrifuging processes like Bari-Sol and Separator-Nobel, the solvents consist of chlorinated hydrocarbons or their blends with benzol. Centrifuges are equipped with scrapers that remove the solid wax cake formed by the crystalline wax. Conventional centrifuges have no scrapers and can handle semi-fluid petrolatum but not the solid paraffin wax.

Dewaxing operations are often conducted in two steps. In the first step already described, oil containing wax is diluted with the solvent, chilled and the wax separated. In the second step, the separated wax is mixed with an additional quantity of solvent and reprocessed for the recovery of the oil still left in the wax. The solvent from this operation contains little oil and is used for diluting the fresh oil charge. This reduces the distillation cost.

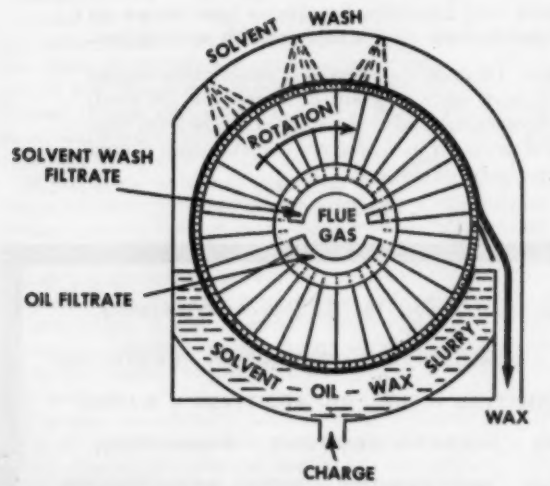

FIG. 6. Typical rotating-drum wax filter, a type used widely throughout the lubricating oil refining industry.

Extraction of Low-Viscosity Index Constituents

This operation is known as solvent refining. This is misleading because solvents are employed also in the dewaxing and deasphalting processes. Extraction of low-viscosity index constituents involves separation of liquids from liquids, and the same "liquid solvent refining" is more appropriate because the other solvent processes separate solid wax or asphalt from the oil.

Liquid solvent processes resemble the liquid sulfur dioxide or Edeleanu Process for refining kerosine. Problems encountered in the extraction of high-boiling, lubricating-oil fractions are different, however, from those encountered in the extraction of low-boiling petroleum distillates. Lubricating oils require much more powerful solvents than those that are satisfactory for extracting gasoline or kerosine. With most of these solvents, the light distillates are completely miscible over a wide temperature range. In lubricating-oil extractions, solvents boiling at comparatively high temperatures can be used. Boiling points of lubricating oils are high, and such solvents can be distilled from them without difficulty.

Extraction efficiency or refining power of solvents com-

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prises two distinct characteristics—"solvent power" and "selectivity." Both characteristics are important in the practical application of solvents. They are not constant but change with temperature and other conditions of extraction, like addition of water.

Solubility of oil in a solvent must be limited at the extraction temperature in order to obtain two layers or "phases." The larger the quantity of oil dissolved by a fixed volume of solvent, the greater is the solvent power of the solvent. Oil extracted by the solvent, however, contains low-viscosity index constituents mixed with some of the high viscosity index constituents. Likewise, the oil layer contains high-viscosity index constituents mixed with some of the low viscosity index constituents. Separations between these oil constituents are not sharp. Some solvents are better in this respect than others; that is, their selectivity is higher.

For instance, a Coastal distillate was extracted with an equal volume of aniline at 75 F and with an equal volume of nitrobenzene at 35 F. Aniline dissolved 12 per cent oil and nitrobenzene dissolved 34 per cent. The solvent power of aniline at 75 F is, therefore, less than that of nitrobenzene at 35 F. In another set of experiments, the same distillates were extracted with 200 per cent by volume of aniline at 75 F and with 45 per cent by volume of nitrobenzene at 35 F. In both experiments, the solvents dissolved 15 per cent by volume of oil. The oil left after extraction with aniline, however, had a 39 viscosity index and that left after extraction with nitrobenzene had a 33 viscosity index. The quantity of the low-viscosity index constituents extracted by aniline was higher than that extracted by nitrobenzene, and the separation between them and the high-viscosity index constituents left in the oil was sharper. This shows that aniline at 75 F is more selective that nitrobenzene at 35 F. This was verified by extracting the oil with the same solvents and at the same respective temperatures to obtain products of an equal viscosity index. The 35-viscosity index oil was obtained by using 100 per cent aniline at 75 F or 50 per cent nitrobenzene at 35 F. The yields were, however, 88 and 78 per cent, respectively. This was an additional proof that aniline at 75 F is more selective than nitrobenzene at 35 F.

Solvent Power and Selectivity

A balance must exist between the solvent power and selectivity of the solvent used for extraction in order to obtain the desired separation between the low and high-viscosity index constituents. If the solvent power is high and the selectivity of the solvent is poor, the quality of the extract differs little from that of the raffinate; i.e., little improvement is observed in oil properties before and after extraction. If the solvent power is low and selectivity of the solvent is high, the quantity of the solvent required for obtaining the desired degree of improvement in oil properties becomes prohibitive.

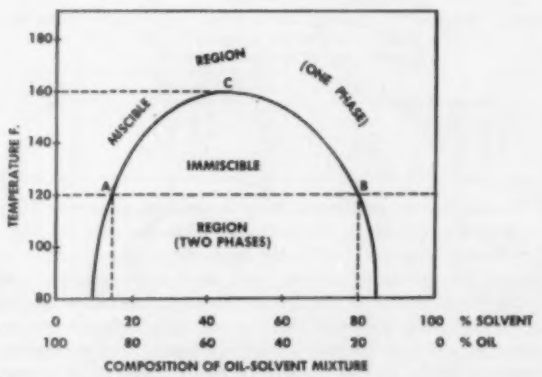


FIG. 7. A typical oil-solvent miscibility diagram.

For instance, a Mid-Continent distillate of 49 viscosity index was extracted with two volumes of chlorex at 77 F. A 75 per cent yield of 55-viscosity index raffinate was obtained. Liquid sulfur dioxide is a very selective solvent but has a low solvent power when applied to lubricating oils. More than 30 volumes of it were needed to obtain an oil of the same viscosity index. Although the yield from liquid sulfur dioxide extractions was high, the quantity of solvent used was prohibitive commercially.

Action of a solvent on an oil can be modified by changing the quantity of solvent or the extraction temperature. Mixtures of solvents can be used, and the solvents can be applied countercurrently to the oil stream. These are the most important variations in the solvent refining technique. The first three can be altered at the discretion of the operator, the fourth one is fixed by the unit design.

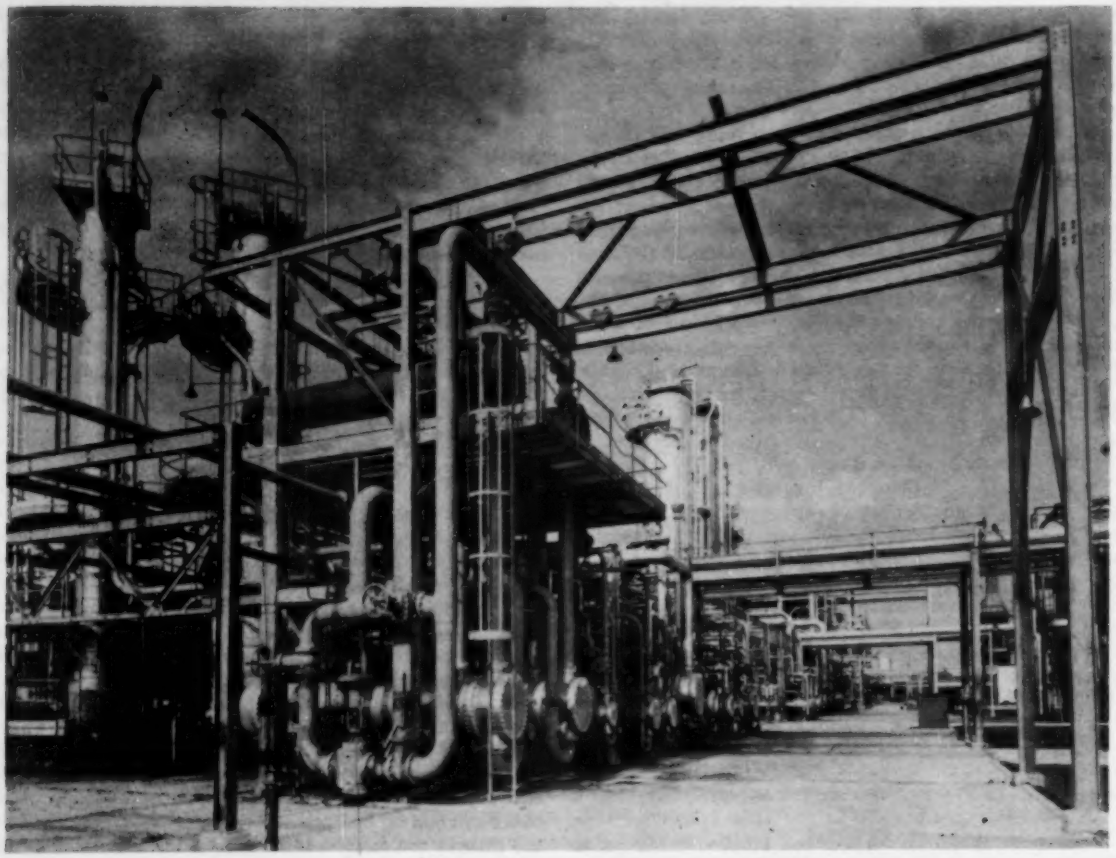
When solvent is gradually added to an oil at a constant temperature, it is completely dissolved by the oil at first. Then a saturation point is reached when the oil can hold no more solvent in solution. If more solvent is added, two layers or phases are formed. One phase is the solution of solvent in oil that is known as the raffinate layer, and the other is the solution of oil in solvent or the extract layer. Commercial solvents are heavier than the oil, and the extract layer rich in solvent separates below the raffinate layer. With some of the laboratory solvents, the position of these phases may be reversed.

A further increase in the quantity of solvent added results in an increase in the volume of the extract layer at the expense of the raffinate layer. Then another condition is reached when all the oil is dissolved by the solvent and the two phases disappear for the second time. Concentrations of solvent and oil that produce only one layer, that is, when too little or too much solvent is used, are said to be in the "miscibility region." Solvent extractions can be made only when two layers are formed, that is, when concentrations of solvent and oil are in the "immiscible region."

Solubility of a solvent in an oil or of an oil in a solvent increases if the temperature is raised. More solvent must be added to the oil before the two phases separate, and less solvent is needed to dissolve all the oil. The miscibility region grows and the immiscible region contracts. By raising the temperature still higher, a temperature is reached when the immiscible region disappears and oil and solvent become miscible in all proportions. This is the temperature limit beyond which extraction of the oil with the solvent becomes impossible. Solvents and oils vary in their miscibility characteristics. These characteristics must be known for each combination of oil and solvent before the extractions can be made.

Miscibility conditions are illustrated by a typical diagram shown in Fig. 7. The diagram shows how a solvent and an oil behave at various concentrations and temperatures. Percentages of oil and solvent in a mixture are shown at the bottom and the temperatures at the side of the diagram. The curve shows compositions of the solvent in oil and the oil in solvent solutions at which the two phases separate. The immiscible region where two layers appear is enclosed by the curve. The temperature corresponding to the peak of the curve shows the limit beyond which extractions are impossible. This diagram is used as follows:

Assume an extraction temperature of 120 F. The dotted line parallel to the base diagram and drawn through the point corresponding to 120 F shows how the mixtures containing various quantities of oil and solvent vary in their miscibility characteristics. At point *a* where the line crosses the curve, two phases are about to form. This point corresponds to a solution of 15 per cent solvent and 85 per



A modern propane deasphalting unit, working in combination with a phenol-solvent extraction unit to produce lubricating oils of high stability and high-viscosity index.

cent oil. Between this point and point *b* where the line crosses the curve for the second time, two phases exist. One phase is formed again at *b*. It corresponds to a solution containing 20 per cent oil and 80 per cent solvent.

Solvent power of a solvent increases but its selectivity decreases as the extraction temperature is raised. Therefore, the viscosity indexes of the oil extracted by the solvent gradually increase and those of the undissolved oil decrease as the temperature goes up. At 160 F or the "temperature miscibility" point shown by letter c, viscosity indexes of the extracted and undissolved oils coincide and the two layers disappear.

Full miscibility diagrams, like the one shown in Fig. 7, are not necessary for practical purposes, and only a small portion of them must be known in the region where the extractions are made. Visualization of such diagrams is important, however, for making decisions about the changes in operating conditions whenever this is required.

Increase in the solvent power of a solvent with temperature is shown by the following example. A Mid-Continent oil was extracted with 150 per cent by volume of chloraniline at 75 F and 100 F. Percentages of oil dissolved by chloraniline at these two temperatures were 36 and 57 per cent, respectively. Decrease in selectivity is demonstrated by the following data. An equal volume of oil, 43 per cent, was dissolved by three volumes of chloraniline at 75 F and by one and a half volume of chloraniline at 100 F. The viscosity indexes of the undissolved oils were 95 and 90, respectively, which is an appreciable difference.

Solvent power of a solvent can be changed only by varying the temperature, but selectivity can be much improved by increasing the number of extraction stages and applying the solvent counter-currently. In the counter-current extractions, the high-viscosity index constituents present in the solvent layer are displaced by the low-viscosity index constituents entering with the charge stock. The larger the number of extraction stages, the more complete is the displacement and the sharper the separation. This is shown by the data presented in Table A, which refer to the extraction of a Mid-Continent oil with 200 per cent by volume of furfural at 200 F.

TABLE A.

Effect of the number of stages on the yield and viscosity index of a Mid-Continent oil extracted countercurrently with two volumes of furfural at 200 F.

Number of stages	Yield, per cent by volume	Viscosity index
1	78.0	84.5
3	73.5	87.0
5	71.5	88.5
7	70.0	89.5

These results are interesting in several respects. They show that the yield of the raffinate decreases and its viscosity index improves with the increase in the number of stages. The decrease in yield and the improvement in viscosity index becomes smaller for each additional extraction stage with both the yield and the viscosity index of the undissolved oil approaching a constant value. The miscibility diagram shown in Fig. 7 changes as the number of extraction stages varies.

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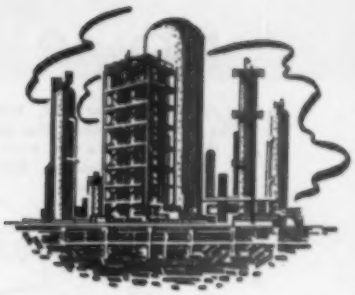

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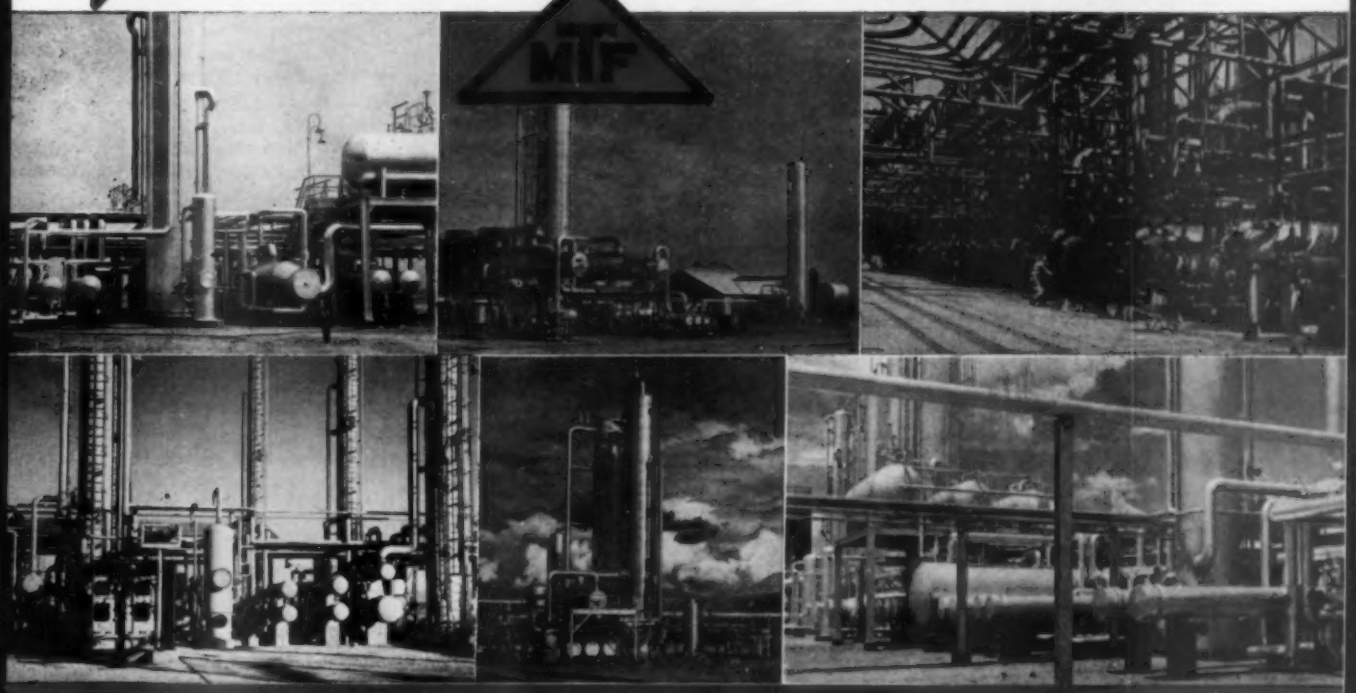

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Jet Fuel Tester Adopted

Problem

Increased jet engine powers necessitated by supersonic flight have made thermally stable fuels one of the biggest problems in jet flying today. Substantial thought and effort have been given to developing laboratory test equipment to help produce such fuels.

Pratt and Whitney Aircraft and DuPont, as well as certain other engine manufacturers, refiners, and other organizations, did important pioneer work in this field.

Solution

Crystallizing the benefit of all the thoughts and accomplishments on this thermal stability problem resulted in the adoption of the Erdco Jet Fuel Coker as the most suitable equipment for evaluating jet fuels under prescribed conditions. Unit is engineered and manufactured by Erdco Engineering Corporation, Addison, Illinois.

Description

With the Erdco coking unit, the test fuel is pumped through an annular heat exchanger. Hot fuel then passes through a heated, sintered-steel precision filter. Fuel flow rate, fuel temperature, and filter temperature can be varied over a wide range to control test severity. Insoluble sediment that is formed during the heating operation deposits on the filter. The time required to achieve a given pressure drop across the filter is a measure of fuel stability. Visual observation of the heated tube is made to estimate heat exchanger fouling tendencies.

Application

More than 35 of these units, produced according to approved specifications, are now in successful use. It has been reported that several fuel coker owners have used the unit successfully to evaluate diesel fuels, fuel oils, and refinery charging stocks, as well as jet fuels.

Typical Jet Fuel Test

Typical operating conditions are a flow rate of 4 lb per hour, a fuel temperature from the heat exchanger of 400 F, a filter temperature of 500 F, and a fuel pressure of 150 psi. Fuel stability is then determined by operating until a pressure drop of 25 in. of mercury is obtained across the filter or until 300 min. have elapsed.

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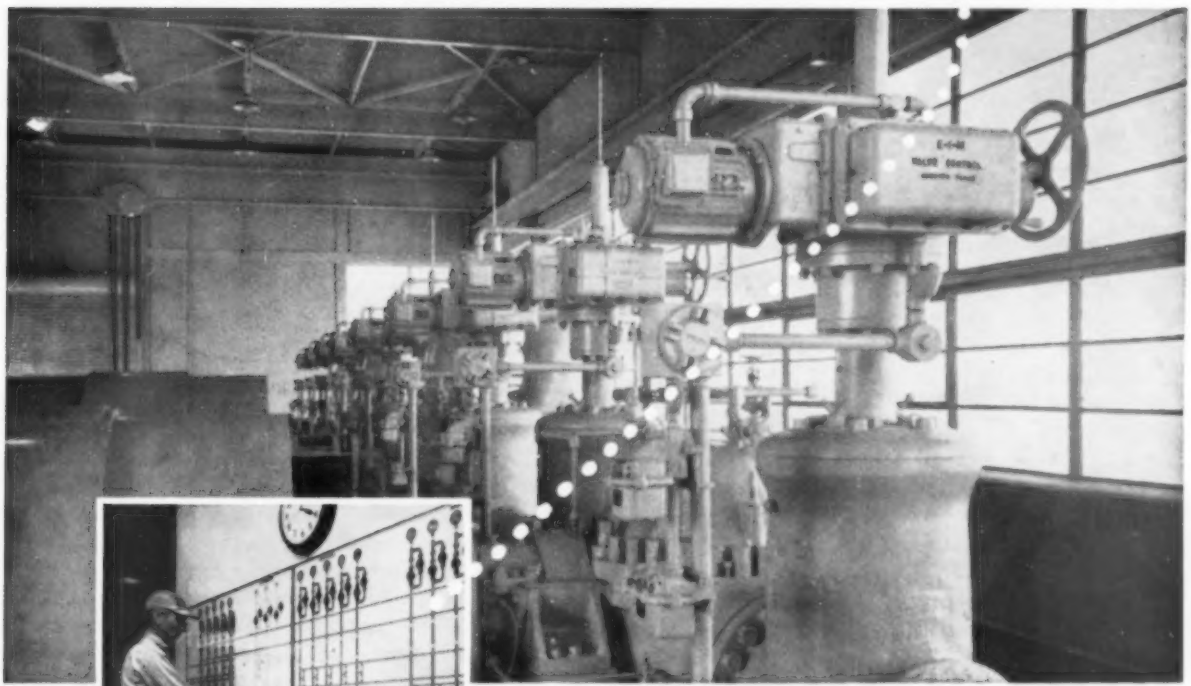
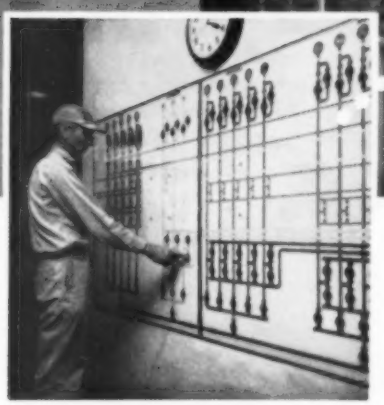
West Texas Gulf Pipe Line Co., like many outstanding transmission lines, makes E-I-M Valve Controls the heart of the modern pumping station—striking a single push-button automatically opens the station block-valve and in sequence the pump suction-valve, pump motor, pump discharge-valve





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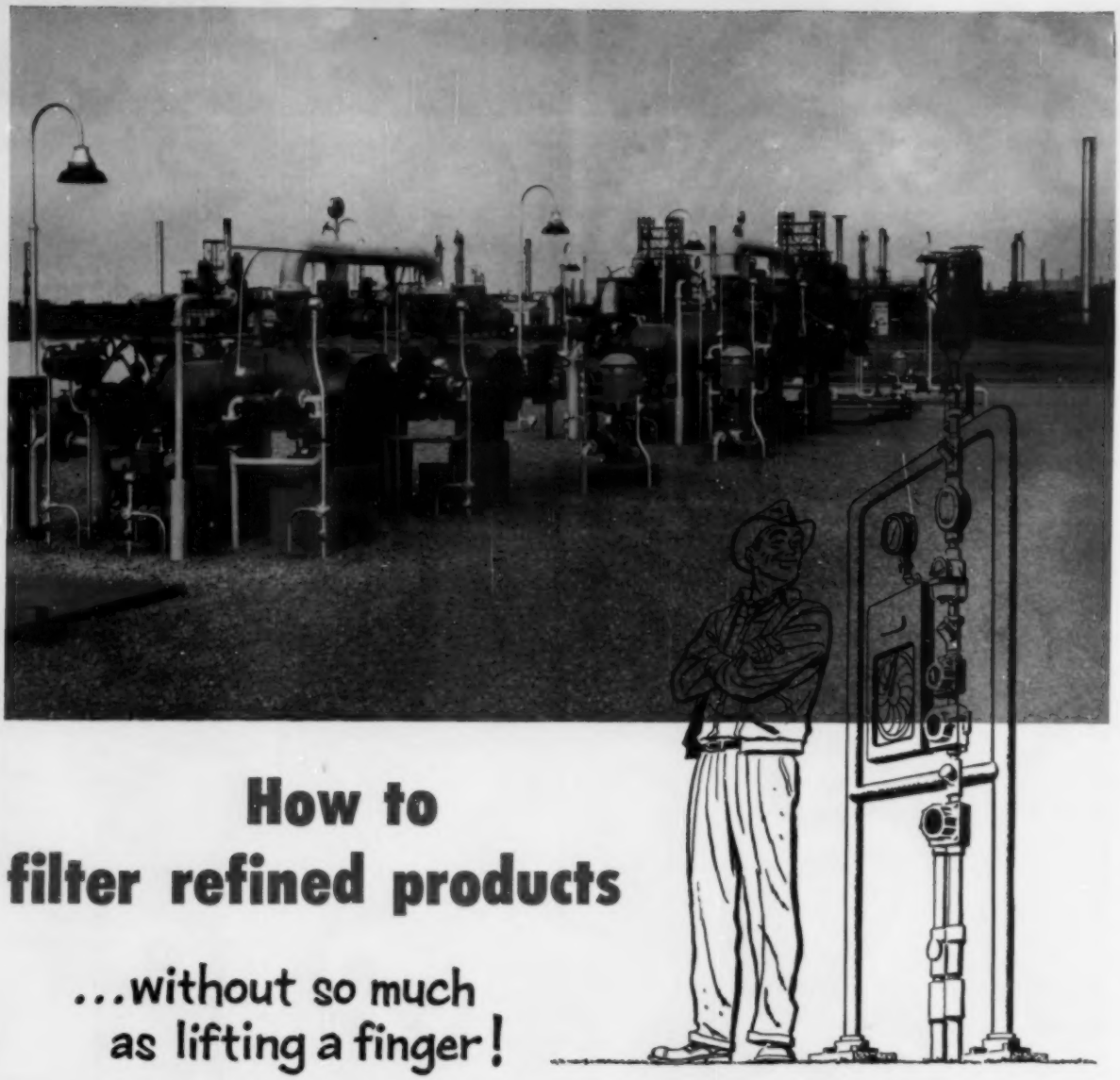

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Jet Strainers offer three distinct advantages over all others:

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(2) Jet Strainers filter the product to any desired degree. Stainless steel strainer baskets are available in mesh sizes up to 400. Filter-aids may be used to further improve the brightness of the product.

(3) Since Jet Strainers are self-cleaning, automatic controls may be applied to the strainers to make their operation fully automatic if desired. Even semi-automatic Jet Strainer operation reduces the process to push-button control and manual opening and closing of a few valves.

The whole story on Jet Strainers has been prepared in booklet form. A copy will be sent gladly on request.

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PIPE LINE DEVELOPMENTS ★ ★ ★

Roundup of Current Planned and Proposed Construction

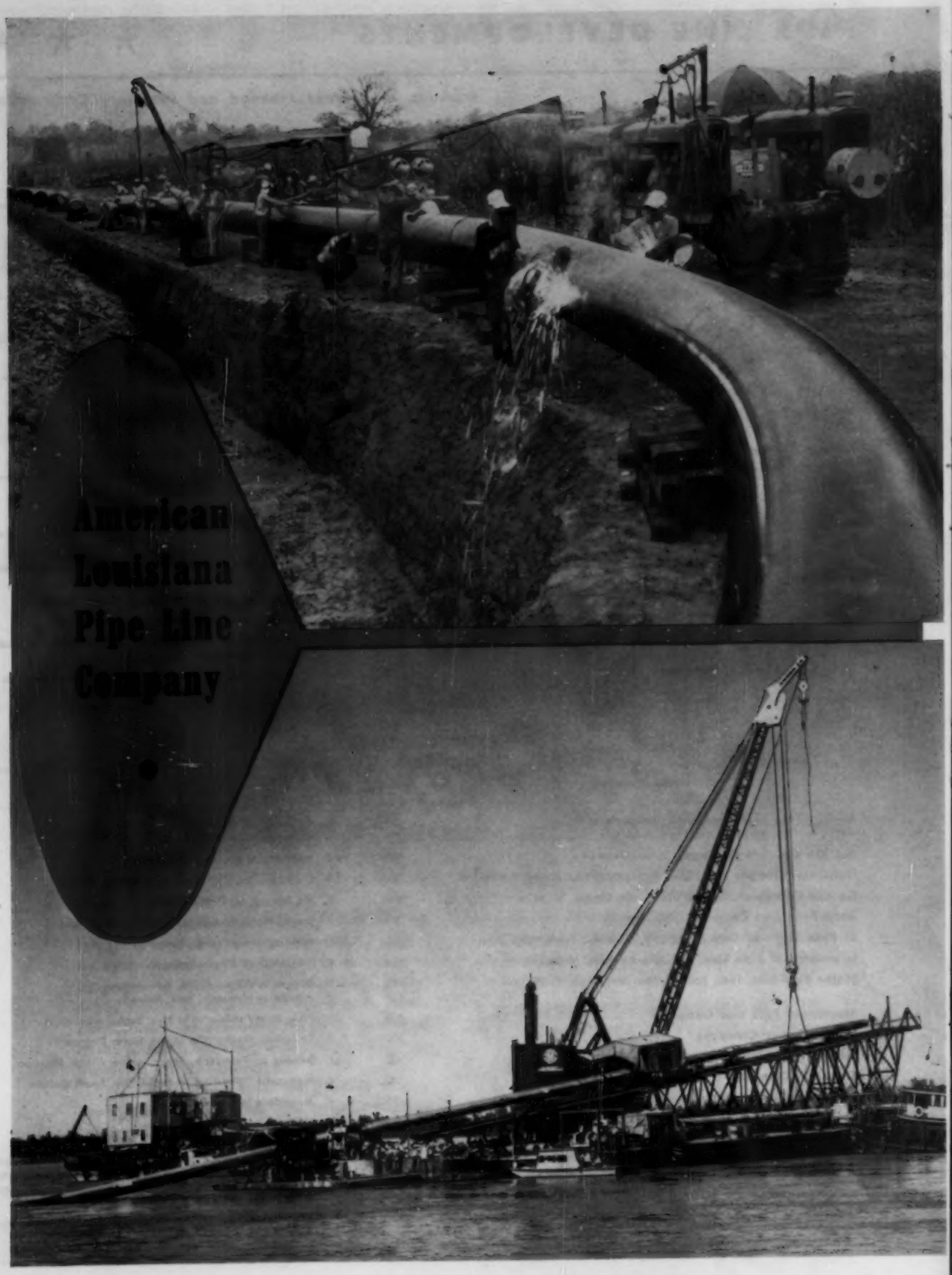
The following tables list the company, mileage, pipe size, and location of proposed pipe line projects — crude, products, and natural gas — reported to The Petroleum Engineer. Company addresses are given where furnished or known.

CRUDE LINES

Name of Company	Miles	Size	Location
Ar-Mex Pipe Line Company, Dallas, Texas	790	12-14	Guernsey, Wyoming to Coolidge, Arizona
Big Horn Pipe Line Company, Cheyenne, Wyoming	150	8	Ash Creek field to Service Pipe Line Company connection
Kaybee Pipe Line Company, Muskegon, Michigan	46	10	Griffith, Indiana to New Buffalo, Michigan
Michi, Inc., Detroit, Michigan	222	10	Highland, Indiana to Alma, Michigan
National Co-Operative Refinery Association, Kansas City, Missouri	30	8	Lyons to McPherson, Kansas
Offshore Gathering Company, Houston, Texas	364	20	Offshore line in Gulf of Mexico from Sabine Pass to Mississippi River
Pasotex Pipe Line Company, Houston, Texas	76	20	Wink to El Paso, Texas, to replace smaller system
Powder River Pipe Line Company, Casper, Wyoming	436	10-16	Williston Basin to Laurel-Billings, Montana, refining area
Richfield Oil Corporation, Los Angeles, California	4	10	Lines in Los Angeles area
Sinclair Pipe Line Company, Independence, Kansas	150 12	20 6	Mexia to Houston, Texas. Replacement of existing line North Madill field to Cumberland field terminal, Oklahoma
Stanmount Pipe Line Company	140	10	Beaver Lake field, North Dakota to Cromer, Manitoba station on Interprovincial Pipe Line
Trans-Border Pipe Line Company	110	—	Skagway, Alaska to Whitehorse, Yukon, Territory
Trans-Prairie Pipe Lines, Ltd., Winnipeg, Manitoba	17	3-6	Lines in Cromer and Virden areas, Manitoba
Union Oil Company, Los Angeles, California	815	—	Considering line from shale oil plant at Rifle, Colorado, to Los Angeles area
U. S. Department of Defense	97	—	Crude line from Elk Hills Naval Reserve to Los Angeles

PRODUCTS LINES

Name of Company	Miles	Size	Location
Ar-Mex Pipe Line Company, Dallas, Texas	60 70	8 8	Coolidge to Phoenix, Arizona Coolidge to Tucson, Arizona
Bell Oil and Gas Company, Tulsa, Oklahoma	140	6-8	Ardmore to Cushing, Oklahoma
California-Oregon Pipe Line System, Crescent City, California	103	6	Crescent City, California to Medford, Oregon
Cosden Petroleum Corporation, Big Spring, Texas	100	6	Big Spring, to Abilene, Texas
Deep Rock Gas Company (LPG Line)	120	6	Tioga, North Dakota to U. S.-Canadian Border
El Paso Natural Gas Company, El Paso, Texas (LPG Line)	60	10	Farmington to Gallup, New Mexico
International Pipe Line, Inc., Minneapolis, Minnesota	132	8	Wrenshall to Minneapolis, Minnesota
Malco Pipe Line, Inc., Roswell, New Mexico	91 138	6 6	Prewitt to Albuquerque, New Mexico Artesia to Newman, New Mexico
Mayflower Pipe Line Company	400	10	New Jersey refineries to New England points
Moore-Stoner Company	200	6	Glendive, Montana to Minot, North Dakota
Phillips Pipe Line Company, Bartlesville, Oklahoma	50	12	Sweeny to Pasadena, Texas, refinery near Houston
Sioux Oil Company	50	6	Newcastle, Wyoming to Rapid City, South Dakota
Standard Oil Company (Ohio) c/o Sohio Pipe Line Company, St. Louis, Missouri	35.5	6	Mogadore to Girard, Ohio
Sun Pipe Line Company, Philadelphia, Pennsylvania	110	14	Marcus Hook, Pennsylvania to Newark, New Jersey
Texas Eastern Transmission Corporation, Shreveport, Louisiana	1168	16-20	Plans to convert the "Little Inch" line between Beaumont, Texas and Moundsville, West Virginia upon completion of new gas facilities. Has FPC aproval to abandon gas service from the "Little Inch"
Winnipeg & Central Gas Company, Winnipeg, Manitoba (LPG Line)	210	6	U. S.-Canadian border to Winnipeg (See also Deep Rock Gas Company listing)


American
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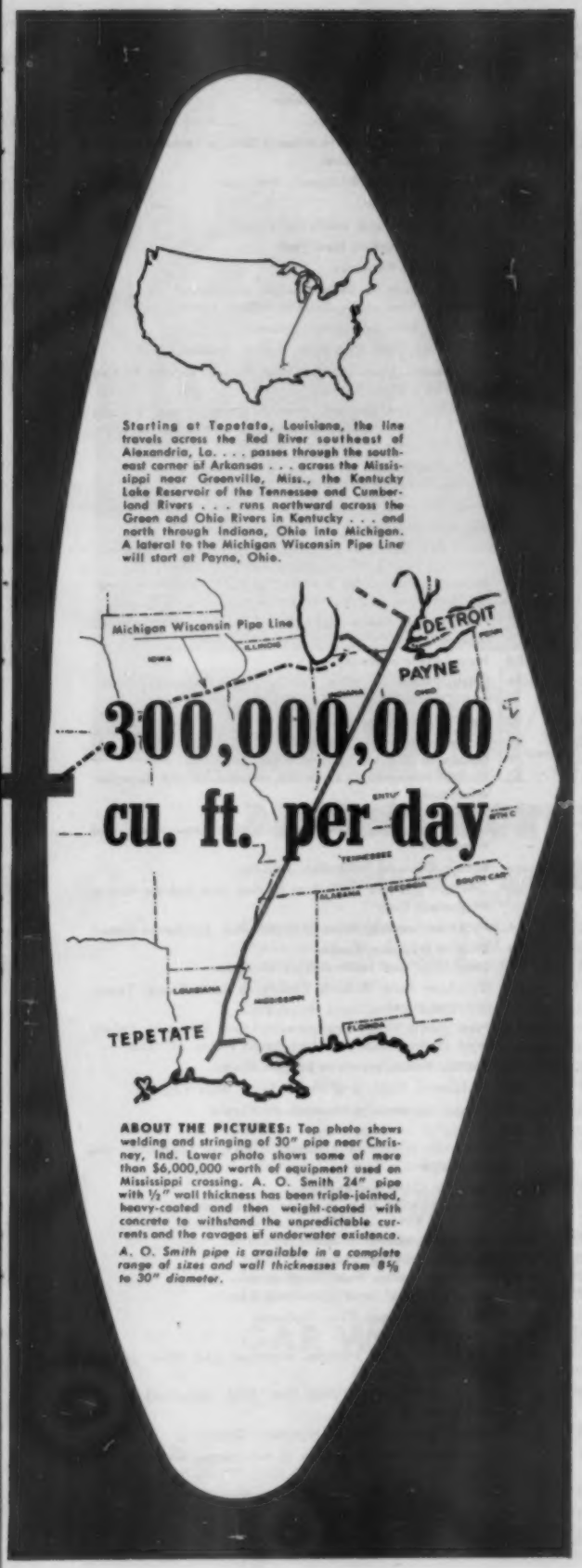
Starting at Tepetate, Louisiana, the line travels across the Red River southeast of Alexandria, La. . . . passes through the southeast corner of Arkansas . . . across the Mississippi near Greenville, Miss., the Kentucky Lake Reservoir of the Tennessee and Cumberland Rivers . . . runs northward across the Green and Ohio Rivers in Kentucky . . . and north through Indiana, Ohio into Michigan. A lateral to the Michigan Wisconsin Pipe Line will start at Payne, Ohio.
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793 Miles of A. O. Smith Line Pipe

THE new American Louisiana Pipe Line is being built to meet the tremendous requirements for additional supplies of natural gas in Michigan, Wisconsin and parts of Iowa and Missouri. When complete it will bring 300,000,000 cu ft of gas per day to these states. This capacity can be increased to 550,000,000 feet per day by the addition of compressor horsepower.

The main line will be 30" in diameter and extend 1000 miles from southern Louisiana to a connection with Michigan Consolidated Gas Company at Willow Run. It will cross 8 states and nine major rivers and lakes, marshes, swamps, rice fields, forests and the mountains of Tennessee, Kentucky and southern Indiana. Also, approximately 78 miles of 24" and 26" main line will be laid in southern Louisiana.

The pipe line system was designed by Ford, Bacon & Davis, Inc., and construction is being done by H. C. Price Company, Houston Construction Company and Brown & Root, Inc.

A. O. Smith Corporation played an important part in this new line by furnishing 758 miles, over 75%, of the 30" pipe from its Houston Mill, A. O. Smith Co. of Texas, and 35 miles of the 26" pipe, together with the 24" heavy wall pipe used for the major river crossings, from its Milwaukee Mill.

For almost 30 years A. O. Smith has held a high-standard of quality control and this quality control has been maintained at every step of the manufacturing process. That's why A. O. Smith pipe made and installed in 1928 is still in operation. That's why so much A. O. Smith pipe has been used in nearly every important high pressure line.

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GAS LINES

Name of Company	Miles	Size	Location
Alberta Gas Trunkline, Calgary, Alberta	315	6-34	Gas gathering system in Alberta fields to serve proposed Trans Canada Pipe Lines
American Louisiana Pipe Line Company, Detroit, Michigan	117	22	Defiance, Ohio to Bridgman, Michigan
Arkansas-Louisiana Gas Company, Shreveport, Louisiana	76	24	Loops in Louisiana
Carolina Natural Gas Corporation	185	2-12	Lines in North and South Carolinas
Central Hudson Gas & Electric Corporation, Albany, New York	48	12	Albany to Kingston, New York
Central Kentucky Natural Gas Company, Charleston, West Virginia	21.1	20-24	New lines in Kentucky
Coastal Transmission Corporation, Dallas, Texas	562	22-26	McAllen, Texas to Baton Rouge, Louisiana
	272	Var.	Gathering lines in Rio Grande Valley, Texas
Colorado Interstate Gas Company, Colorado Springs, Colorado	110	6-8	Julesburg area to Denver, Colorado
El Paso Natural Gas Company, El Paso, Texas	413	34	Farmington, New Mexico to Topock, Arizona
Houston Texas Gas & Oil Company, Houston, Texas	961	12-20	Baton Rouge, Louisiana to Miami, Florida, serving Florida area with various laterals
Iroquois Gas Corporation, Buffalo, New York	36	Var.	Gathering and delivery lines in underground storage area in Chautauqua, Cattaraugus and Erie Counties, New York
Lone Star Gas Company, Dallas, Texas	230	30	Cotton County, Oklahoma to Fritch, Texas
	205	24	Snyder, Texas to Cotton-Fritch line
Michigan-Wisconsin Pipe Line, Detroit, Michigan	252	4-24	Loops on system in Missouri, Iowa, Illinois, and Wisconsin
Michigan-Consolidated Gas Company, Detroit, Michigan	25	12	Sparta to Muskegon, Michigan
Midwestern Gas Transmission Company, Houston, Texas	1112	12-24	Main line from U. S.-Canadian Border near Emerson, Manitoba-Noyes, Minnesota to Portland, Tennessee
	648	3-18	Laterals off main line to serve communities in Minnesota, North Dakota, and Wisconsin
Montana-Dakota Utilities Company, Minneapolis, Minnesota	41.8	12	Tioga-Beaver Lodge field in North Dakota to main transmission line
Morganfield Natural Gas Company	31	4-6	New lines in Kentucky
Natural Gas Pipe Line Company of America, Chicago, Illinois	350	20-26	Fritch, Texas to Wise County, Texas, through Southwest Oklahoma
Nevada Natural Gas Company, Las Vegas, Nevada	114	10	Loop of present system
Northern Natural Gas Company, Omaha, Nebraska	15	24	Loops on system in Nebraska
	28	24	Ogden to Redfield storage area, Iowa
	168	20	St. Paul-Minneapolis to Duluth, Minnesota and Superior, Wisconsin
	163	10-12	Main lines in South Dakota
	307	Var.	Branch lines in South Dakota, Minnesota, Iowa, and Wisconsin
Northwest Utilities, Ltd.	42	—	Bonnie Glen to Edmonton, Alberta
Offshore Gathering Company, Houston, Texas	364	30	Offshore gas line in Gulf of Mexico from Sabine Pass to Mississippi River
Pacific Gas & Electric, San Francisco, California	150	34	Loops on Topock, Arizona to Milpitas, California system
Panhandle Eastern Pipe Line Company, Kansas City, Missouri	20	24	Rolla to Hugoton, Kansas
	74	4-16	Loop lines and replacements on system
Phillips Petroleum Company, Bartlesville, Oklahoma	22	20	Qyinduno field, Roberts County to Rock Creek, Texas, gasoline plant
Pioneer Natural Gas Company, Amarillo, Texas	261	3-22	New lines, loops, replacements and irrigation feeder lines in the Panhandle and South Plains of Texas
Pine Tree Natural Gas Company	204	—	Boston, Massachusetts to Bangor, Maine
Shenandoah Gas Company, Winchester, Virginia	39	3-8	Middleton, Virginia to Martinsburg, West Virginia
Southern Counties-Southern California Gas Companies, Los Angeles, California	236	30	Topock, Arizona to Newhall, California
Southern Natural Gas Company, Birmingham, Alabama	59	—	Loops on system in Alabama, Georgia, Louisiana, and Mississippi
Tennessee Gas Transmission Company, Houston, Texas	221	26-30	Loops in Ohio and Kentucky
	100	—	New gathering lines in Texas and Louisiana
	162	—	Loops in Kentucky, Ohio, and Pennsylvania
	335	6-24	Gathering system in South Louisiana
Texas Eastern Transmission Corporation, Shreveport, Louisiana	422	30	McAllen to Vidor, Texas
	530	30	Loops on system from Texas to New Jersey
	180	Var.	Supply, lateral, and gathering lines
Texas Gas Transmission Corporation, Owensboro, Kentucky	105	10-12	Eunice to Morgan City, Louisiana
	81	8-30	Loops on system
Trans Canada Pipe Lines, Ltd., Calgary, Alberta	2247	14-24	Alberta area to Toronto, Montreal, and other eastern Canadian areas
Transcontinental Gas Pipe Line Corporation, Houston, Texas	12.3	—	Gathering lines in Live Oak field, Vermilion Parish, Louisiana
Union Gas Company of Canada	180	—	Dawn Storage Field to Hamilton, Ontario
United Gas Pipe Line Company, Shreveport, Louisiana	63	—	Additional lines on system in Mississippi, Alabama, and Florida
United Natural Gas Company	50	12	Elk County to Jefferson County, Pennsylvania
Utah Natural Gas Company, Salt Lake City, Utah	40	16	Orem to Salt Lake City, Utah
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Virginia

Gar Wood Buckeye **314**

DELIVERS MORE DITCH PER DOLLAR!

Make this 4-way comparison and see why...

Compare useable power at the wheel—On a Buckeye 314 *more* of the engine's power is available at the digging wheel. Anti-friction bearings make the difference! They reduce power loss, cut fuel bills. Fluid coupling provides a smooth flow of power, cushions shocks in tough digging.

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Compare maintenance costs—Downtime is kept to a minimum. Unit-type construction makes servicing easy. Digging wheel trucks are flush lubricated, sealed against water and dirt, easily adjustable for wear. "Quick Change" rooter bits last longer, can be replaced easier and at a much lower cost.

Compare flexibility to meet job conditions—Only Gar Wood-Buckeye offers a complete choice of factory engineered options to handle every application and digging condition!

The Gar Wood-Buckeye 314 digs to 6 feet deep, 16 to 30 inches wide in 2-inch steps. Call your Gar Wood-Buckeye dealer and see how much *more* you get in a Buckeye! Or, write to: Customer Service Department, Gar Wood Industries, Inc., Wayne, Michigan.

GAR WOOD INDUSTRIES, INC.

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H.B. ZACHRY CO.
PIPE LINE DEPARTMENT
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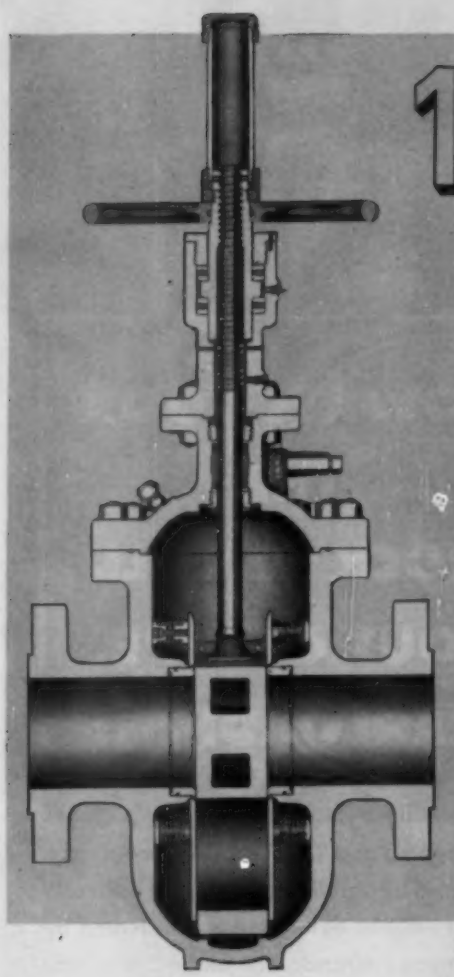
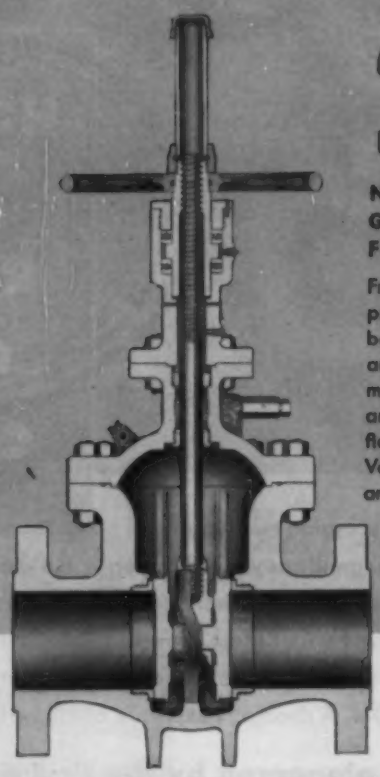
CRANE

Announces Two New PIPE LINE VALVES



1 **NEW CONDUIT-TYPE GATE VALVE ONE-PIECE DISC; NON-DIRECTIONAL FLOW**

Bottom seated, "O" ring-sealed seat rings are self-aligning, and self-sealing on closure—one-piece conduit-type disc uses line pressure for tight seating, does not need excessive stem thrust—spring loaded disc plates prevent loss of grease and entrance of line dirt into body. Sizes, 2 to 30-inch, full-way; venturi patterns also available.



2 **NEW DOUBLE DISC GATE VALVE WITH FREE-TO-ROTATE DISCS**

Free-to-rotate discs distribute wear, prolong life—machined guides in body accurately control disc clearances—annular wedging surfaces maintain perfect disc alignment and compensate for any body deflections imposed by line strains. Valve operation is easier, surer, and maintenance is greatly reduced. Sizes, 4 to 24-inch.

BOTH LINES OF VALVES HAVE bolted "O" ring-sealed bonnet-joint; 2-piece bonnet and yoke; fully enclosed yoke for stem thread protection and lubrication; plastic packing with injector-check valve; supporting legs cast on body; pressure relief valves.

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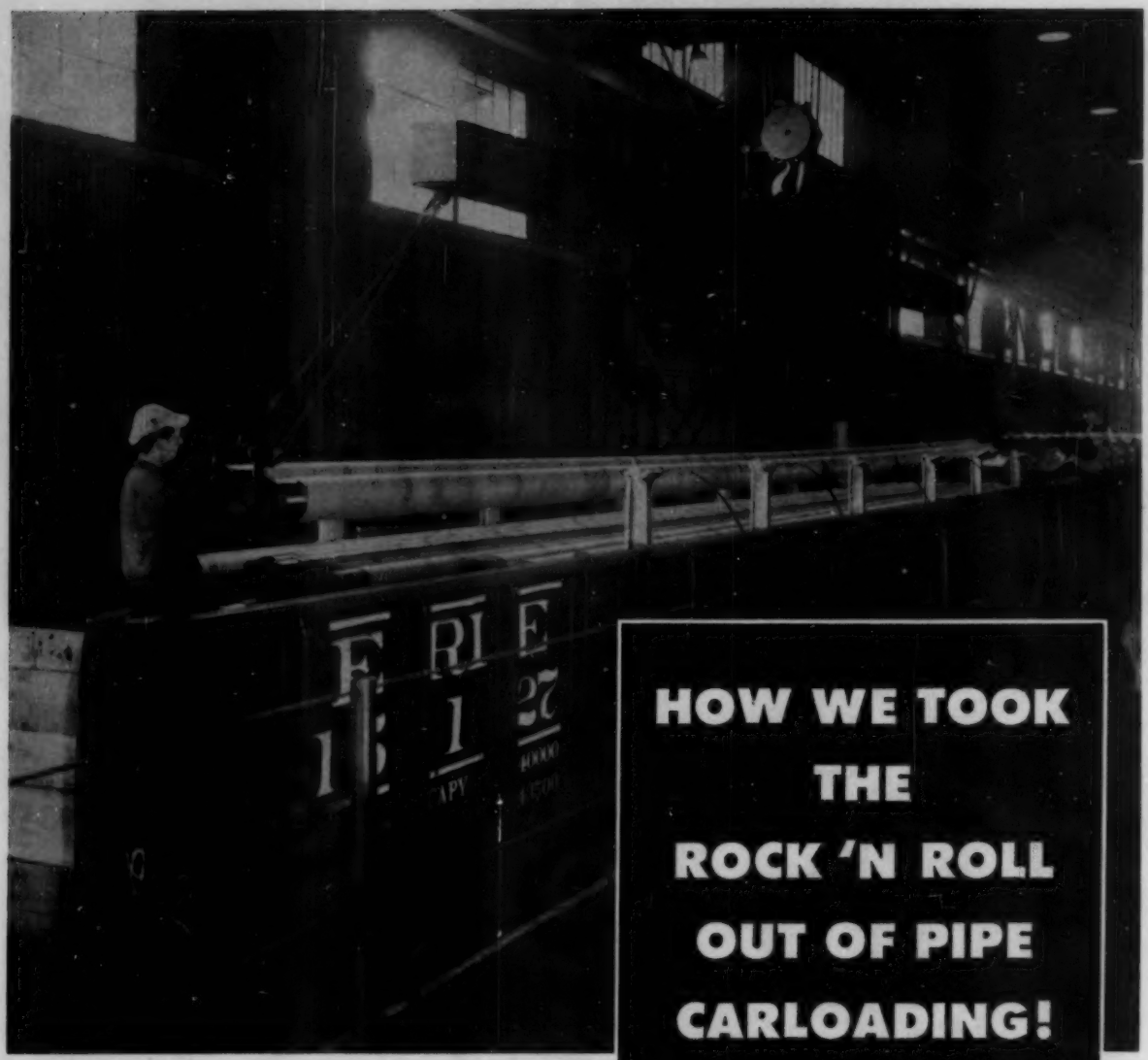

HOW WE TOOK THE ROCK 'N ROLL OUT OF PIPE CARLOADING!

The workman above is easing two lengths of pipe into a gondola as gently as you'd place eggs in a shopping bag. Each length fits snugly into place. Then all are tied down by steel bands and protected by padding so they can't roll, rock, shift, or abrade in long haul or short. This "Unit-load" system was developed and *patented* by HILL, HUBBELL and was given to the Association of American Railroads, who made it their official specification, MD-4. A dramatic example of HILL, HUBBELL know-how, "Unit-loading" is—

Another "first" pioneered by the first name in pipe protection . . .

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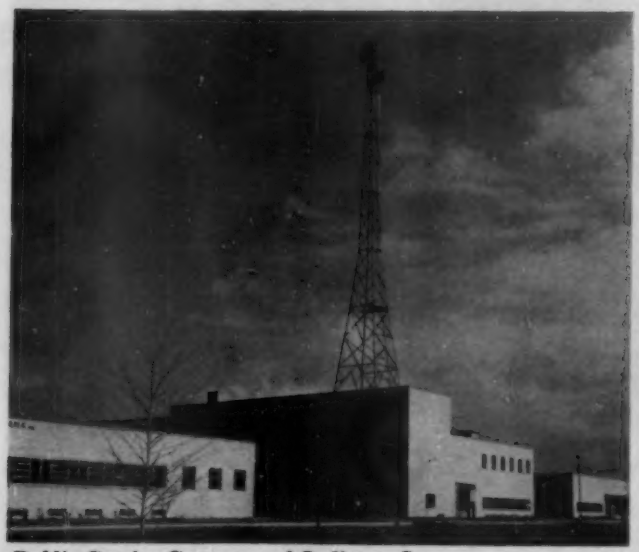


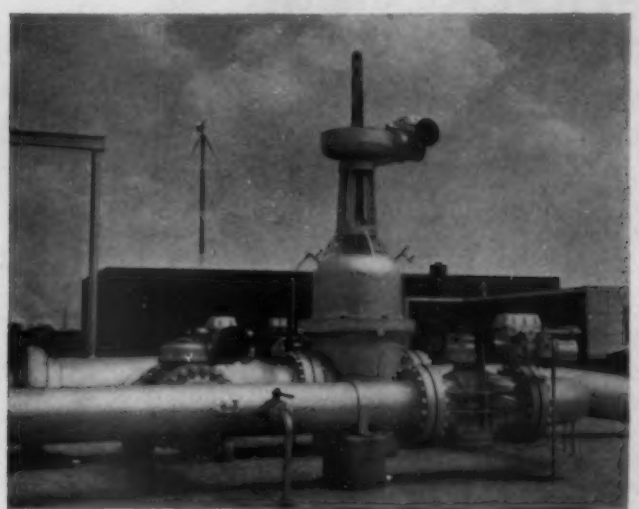
Public Service Company of Indiana, Inc.

Microwave radio aids in controlling supply of electricity for the state of Indiana. Four branches of a G-E Microwave system—combining voice and telemetering channels—originate at utility headquarters in Plainfield. From this hub regional demands are controlled according to local needs. Load control information obtained by remote control telemetering is analyzed, then transmitted to generating stations in necessary areas. Entire electrical power system is linked solidly by microwave radio.

Busy Tower

Antenna receives, transmits, or relays voice or telemetering signals. Antennas like these link headquarters with generating plants and sub-stations over a wide area.

P.S.I.'s microwave network provides utmost dependability because of standby equipment, fail safe feature, and because equipment can be concentrated at specific locations where it can be fully protected and easily maintained.



Sinclair Pipe Line Company

Microwave radio helps Sinclair coordinate flow of crude oil and oil products over many states—even turns pumps on and off. 7 voice, 4 telemetering channels link Cushing, Oklahoma and East Chicago, Indiana. Another channel permits remote control of 16 VHF radio base stations along the line which provide communication between over 100 radio-equipped vehicles and any company office in the microwave system. System is capable of providing up to 12 additional channels as needed.

Are microwave circuits your answer, too?

It depends.

What kind of service do you provide, how do you do it?

Let's assume that instant control and coordination of many functions, over long distances, are vital to your needs. Then you *should* investigate microwave because it is dependable, economical, and inexpensive to add additional circuits.

The services shown here *need* dependable voice and signal circuits. One controls the flow of crude oil and oil products over many states. The other uses microwave to link electric power facilities throughout one state.

Both use G-E Microwave Equipment for efficiency and economy. For additional microwave information, write: *General Electric Co., Microwave Equipment, Sect. X9236, Electronics Park, Syracuse, N.Y.*

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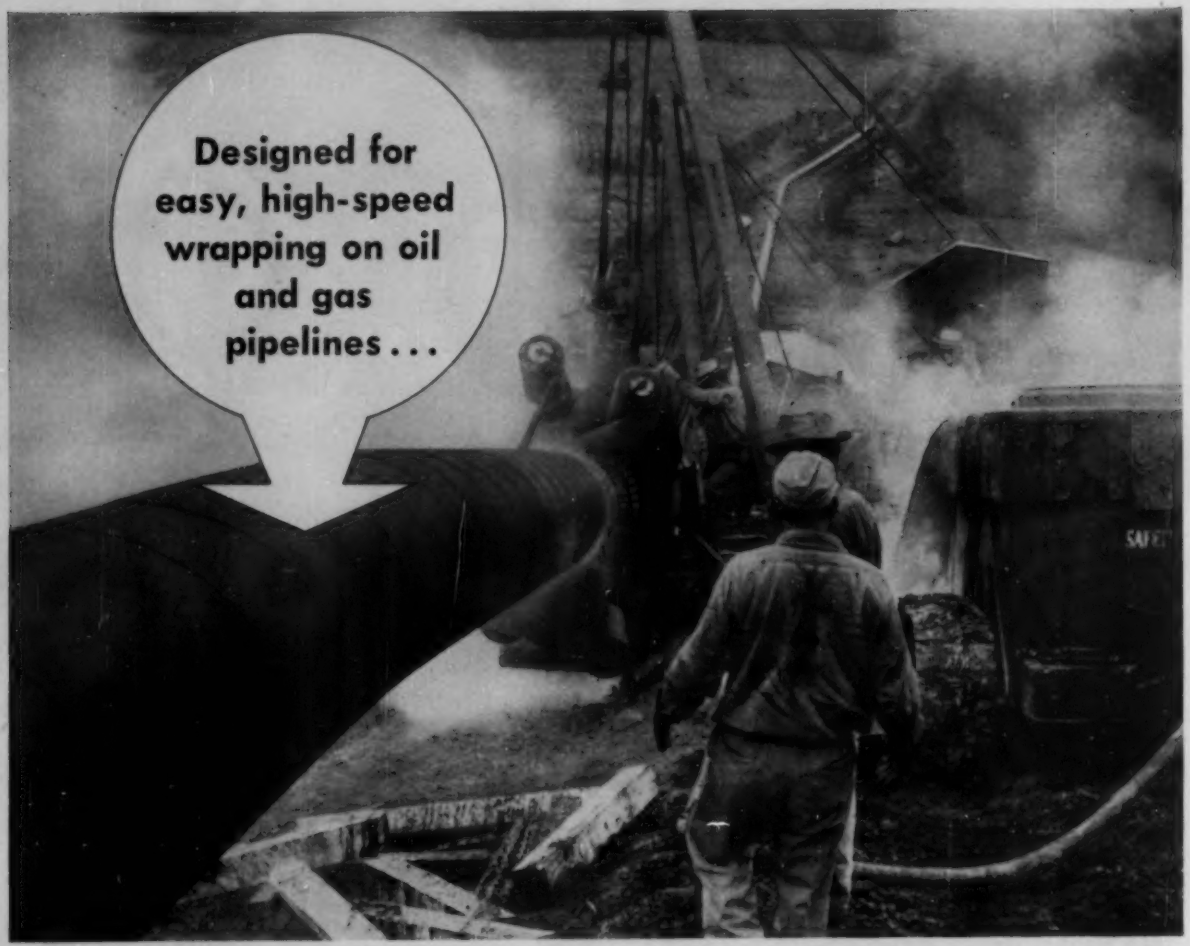


Johns-Manville TRANSHIELD® ASBESTOS PIPE LINE FELT

goes on fast, restricts soil stress, cuts maintenance

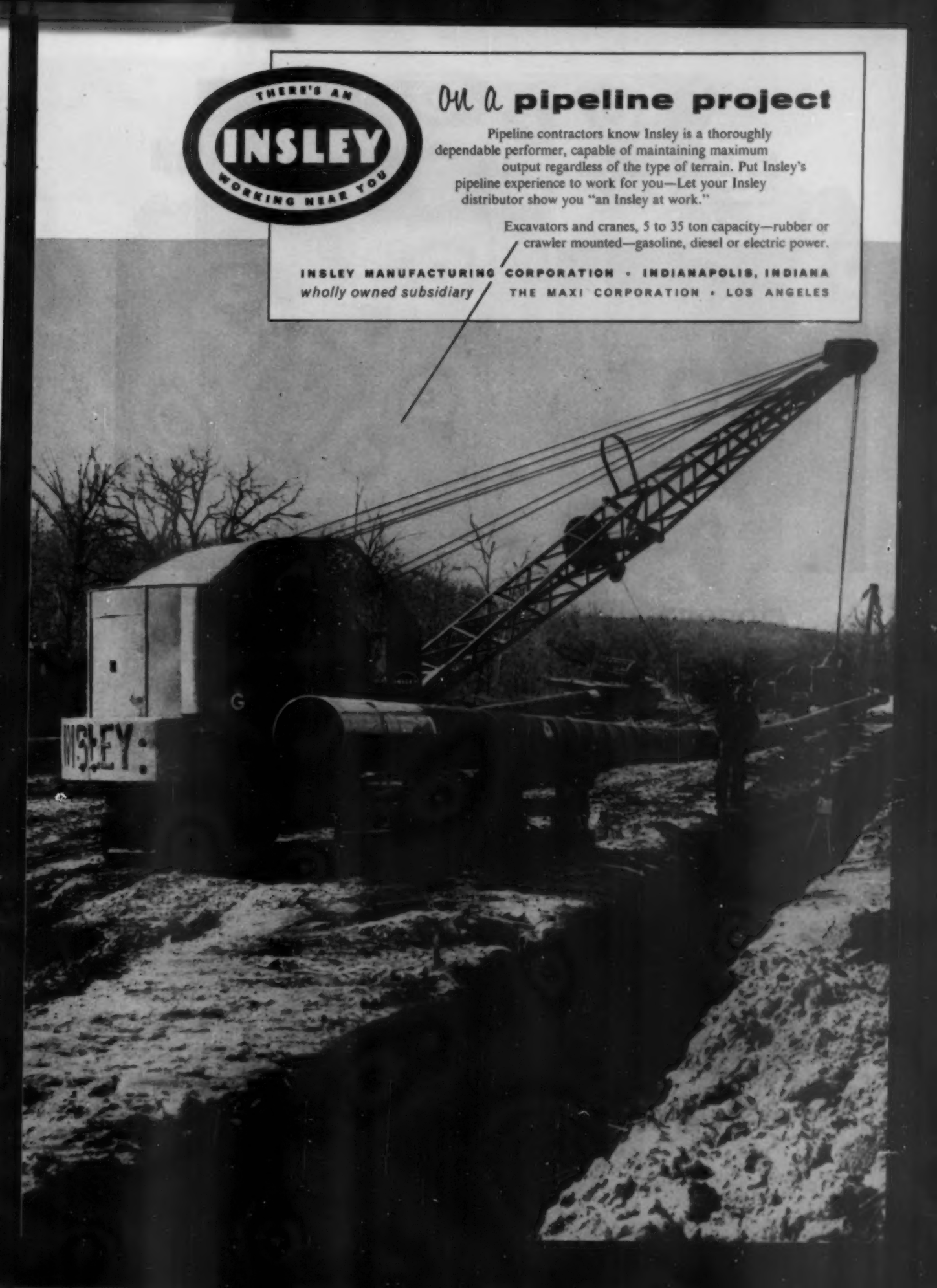
ON job after job, pipe line men have found that Transhield Asbestos Pipe Line Felt meets the need for an economical asbestos shield that is effective in average soil conditions.

Contractors like Transhield because its special reinforcement makes it ideal for easy, high-speed application by modern machine methods. Consisting of a lightweight coal-tar-saturated asbestos felt, it is reinforced with continuous glass yarns parallel-spaced on ¼" centers. Transhield's light weight permits the use of 800-ft. rolls which increases application speeds since fewer stops for roll changes are required.

Transhield provides a continuous membrane between the pipe line enamel and the soil. It works effectively in preserving a continuous protective film of enamel on the pipe. During construction, it guards the enamel. After installation, it reduces the cold flow of the enamel, and acts as a surface barrier to restrict soil stress.

For further information write to Johns-Manville, Box 60, New York 16, N. Y.; in Canada, 565 Lakeshore Road East, Port Credit, Ontario.

Johns-Manville PRODUCTS FOR PIPE LINE PROTECTION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Pipeline contractors know Insley is a thoroughly dependable performer, capable of maintaining maximum output regardless of the type of terrain. Put Insley's pipeline experience to work for you—Let your Insley distributor show you "an Insley at work."
Excavators and cranes, 5 to 35 ton capacity—rubber or crawler mounted—gasoline, diesel or electric power.
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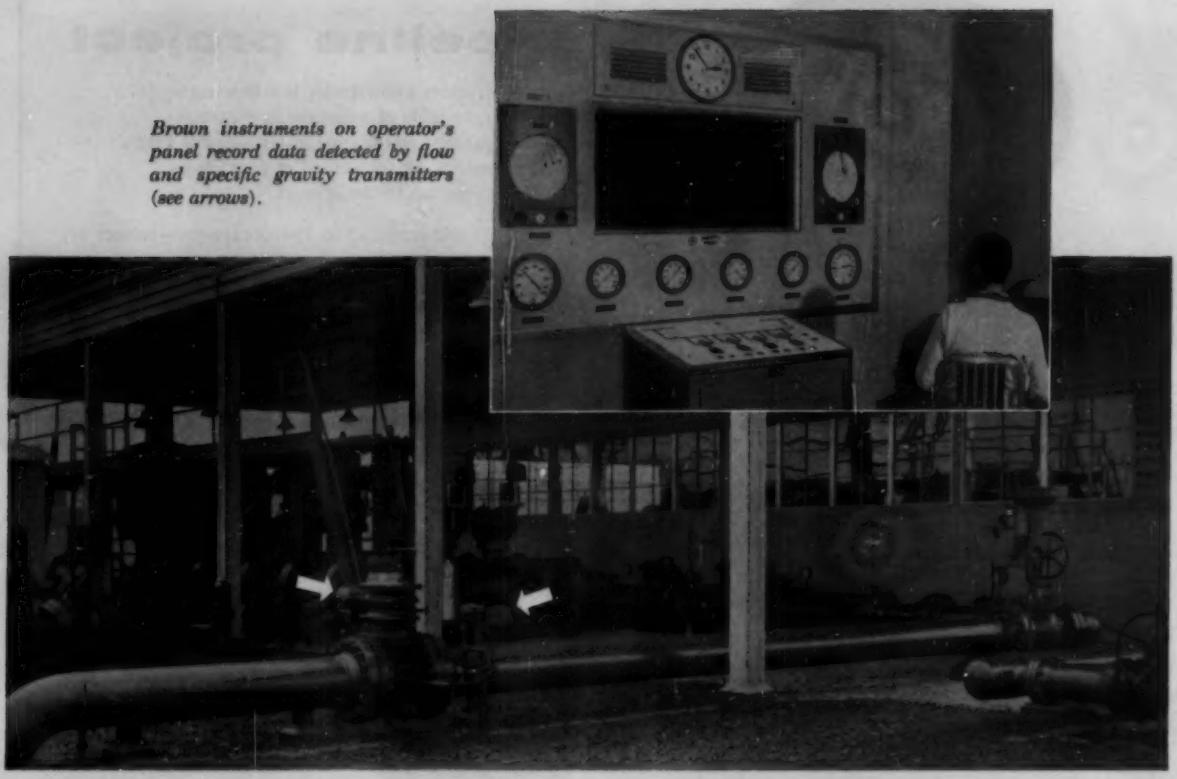

Brown instruments on operator's panel record data detected by flow and specific gravity transmitters (see arrows).

Honeywell custom-designed control coordinates pumping station operation

EFFICIENT, fingertip control makes for simplified operation at Buckeye Pipe Line Co.'s Macungie, Pa. pumping station. A coordinated instrumentation system, designed by Honeywell for the individual needs of this station, gives full automatic control of station throughput, with an absolute minimum of supervision.

Two instruments give the operator an accurate picture of how the station is functioning. A Brown Single Pilot Dual Pressure Controller measures and records both suction and discharge pressures . . . and regulates a diaphragm valve in the discharge line. The Controller automatically transfers control action, actuating the valve only when suction pressure gets too low or discharge pressure too high. A three-pen instrument records specific gravity of fluid in the inbound and outbound lines, and flow in the outbound pipe.

Honeywell equipment covers all critical instrumentation requirements. In addition to the panel-mounted recorders, this station uses a Brown *Differential Converter* for remote flow transmission . . . Brown specific gravity transmitters...and Honeywell valves for flow control and for venting pump cases.

Your local Honeywell sales engineer will be glad to discuss how this versatile line of instrumentation can be engineered into a system that exactly fits your own station control requirements. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA:** Write for Composite Catalog No. 5002.

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

How perfectly simple —this Fast's Coupling with purely mechanical flexibility!

1. A hub is keyed on each shaft. Hubs are splined at maximum distance from shaft ends.
2. Floating sleeves surround hubs. Sleeves are splined to engage hub splines.
3. Sleeves compensate for shaft misalignment by assuming neutral position between two hubs.
4. Because of distance from shaft end, any misalignment between splines is mere fraction of same misalignment between shafts.
5. Sleeves carried on bearing rings located on transverse center line of hub spline faces (the load-carrying surfaces) — no crank action, no vibration.
6. Lubricant is centrifugally forced into spaces between engaged splines, forming a film.

For 35 years the most positive, dependable means of coupling machines to their power source . . . Fast's Couplings have no parts subject to repeated bending, tension or compression. Because there is no metal-to-metal contact, *there is no wear*—in fact, many Fast's Couplings in use for over 30 years show no signs of wear when disassembled! No leather, plastic or rubber oil seals. Lubricant film distributes pressure over a considerable area, diminishing localized stress at pressure points on the load-carrying teeth. Perfectly simple? Yes . . . and foolproof!

For coupling catalog, technical advice or assistance from Koppers field engineers, write: KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* 3203 Scott Street, Baltimore 3, Maryland.

THE ORIGINAL **FAST'S Couplings**

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This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Industrial Gas Cleaning Apparatus, Aeromotor Fans.
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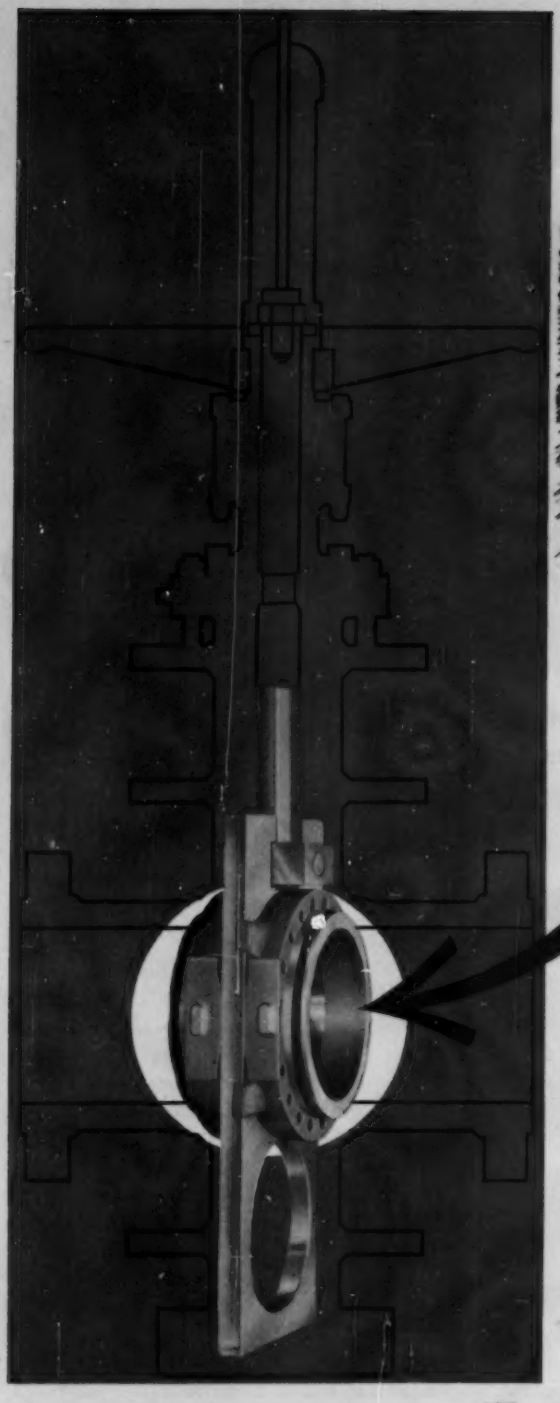

the WHOLE VALVE is RIGHT HERE

- **Line pressure is isolated in the conduit while valve is open or closed**
- **Bubble-tight seal on both sides of the gate may be checked after each operation**

Grove Seal-O-Ring Gate Valves with the exclusive new fabricated body design offer an extra wide margin of safety, because line pressure is isolated in the conduit when the gate is either full open or closed. This means that the body is required only as a framework for the simple operating mechanism, and to prevent loss of fluid or gas while gate is being moved. When gate is open or closed, body may be drained or vented to atmosphere – and integrity of both upstream and downstream seals may be checked by means of a simple tell-tale valve on the body. For 2" to 36" size requirements for all wanted working pressures.

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GROVE SEAL-"O"-RING Gate Valves

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GROVE SEAL RING GROVE SIMPLICITY ACCURACY SAFETY

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What Topaz Can Do For You?

Topaz is a sales and service organization offering you complete lines of nationally recognized pipeline supplies and equipment plus the consulting and supervisory services of experienced engineers. You can call Topaz night or day, with assurance that your needs will receive prompt personal attention.

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Topaz* sales engineers plan and supervise** hot tapping operations on gas, steam, water, products and chemical lines without costly shutdown. Hot tapping equipment may be contracted, leased or purchased. Topaz service includes consultation, supervision and instruction of company field personnel on use of purchased equipment.

Agent for T. D. Williamson, Inc.
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L & M Marker-vents on highway and railroad casing vent pipes have proved both effective and economical. Less expensive than a field-welded vent hood, the aluminum alloy L & M Marker-vent will last the life of the line. Custom designed sign panels with your company name and emblem are available in your choice of colors. Sizes available for 2", 3" and 4" pipe. L & M products, distributed by Topaz* also include standard safety signs, well markers and aerial view markers.

Sole distributor for L & M products.

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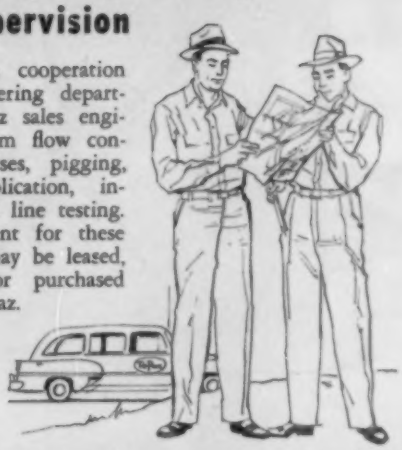
Working in cooperation with engineering departments, Topaz sales engineers perform flow condition analyses, pigging, stopple application, inspection and line testing. All equipment for these operations may be leased, contracted or purchased through Topaz.



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All cathodic protection equipment and supplies, including rectifiers, anodes, coke breeze, pipe wrap and pipe coatings are available from one supplier . . . Topaz*. This means savings to you in time and paper work.

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Other supplies available from Topaz:

- valves
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- Plus all other equipment or supplies necessary to complete your project.

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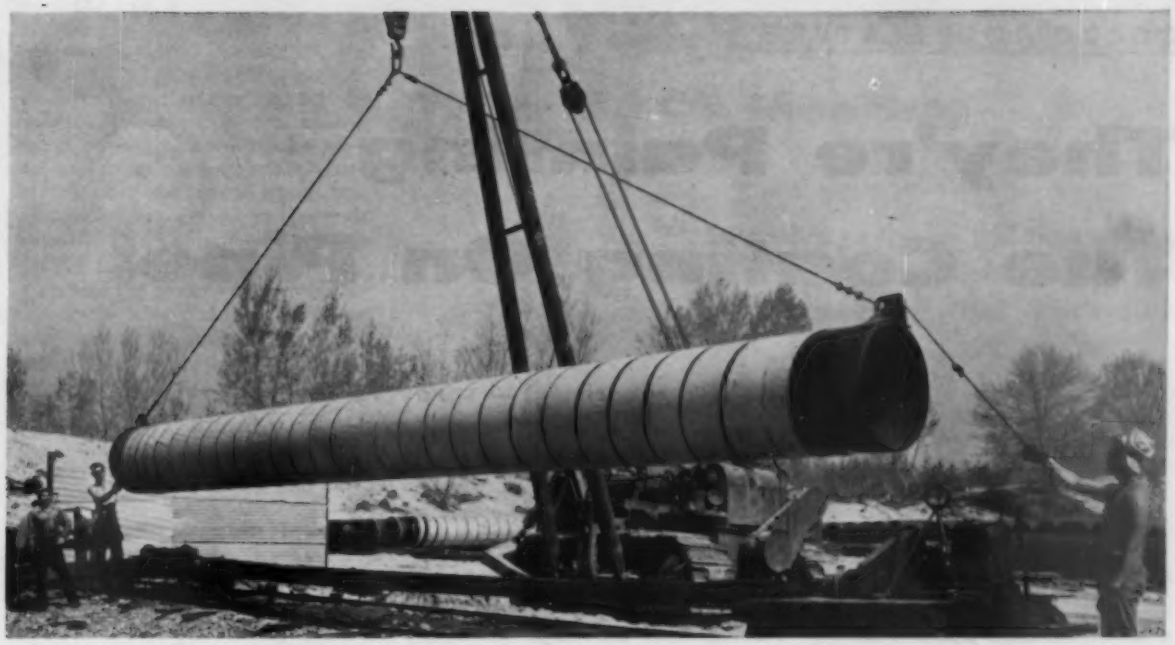

KING SIZE PROTECTION: 36" pipe, mill coated first with NO-OX-ID 6X for bonded insulation against moisture, then shielded with No. 7 NO-OX-IDized Wrapper and Service Coat for added electrical resistance and protection against soil stress. Finally, a kraft wrap to protect from damage in handling operations. This is long-term pipeline protection at its best.

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PROTECTION BY THE MILE: A NO-OX-ID coating combination is uniformly applied over-the-ditch by this traveling type machine. The NO-OX-ID 6X Base Coating is covered with an unbroken shield of No. 7 NO-OX-IDized Wrapper. The fabric side of the wrapper is an excellent surface for bonding a service coat.

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Wherever pipelines go—into long or short line service, through rough terrain or rolling plains—there is a NO-OX-ID coating combination plus a method of application for long-term protection against corrosion.

WRITE FOR BULLETIN "Protecting Underground Pipe from Corrosion with NO-OX-ID and NO-OX-IDized Wrappers" tells the story. Your copy is ready upon request.

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Please send my copy of "Protecting Underground Pipe from Corrosion with NO-OX-ID and NO-OX-IDized Wrappers."

Name..... *Title*.....

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City..... *Zone*.... *State*.....

Dearborn NO-OX-ID®

Protecting Metal Against Corrosion Since 1887

CORROSION FEATURE

They're Painting The Coating On Pipe!

A new experiment — spraying new epoxy resin, coal tar coating on pipe like whitewash on a fence. The product has high electrical resistance, low water absorption, and seems tough as a boot.

Donald M. Taylor
Gulf Coast Editor

PIPE line construction may be revolutionized during the next few years if an experimental pipe line coating lives up to its laboratory tests.

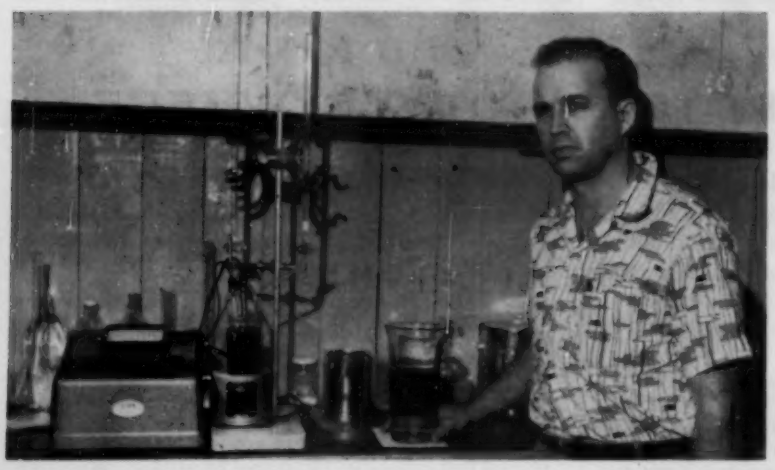
The new coating is made of epoxy resin and coal tar with an amine curing agent added just before it is applied to the pipe. At the time of use, it has the consistency of ordinary house paint. It is designed to be brushed or sprayed onto the pipe in thicknesses no greater than whitewash on a fence.

The coating has a dielectric strength of about 400 v per mil of cured thickness, and the developers believe a film of 6 to 20 mils will be sufficient to protect buried pipe lines as well as any coating in use today.

A major gas transmission company is experimenting with the new product, using it to coat 6-in. pipe for an 8-mile-long south Louisiana pipe line. In this instance, company engineers plan to find out everything possible about the coating. Their test will be severe.

The pipe will be cleaned and coated in Houston, Texas. After it has cured (this takes about three days) it will be shipped to Louisiana. It will receive no more than normal care in shipping, and the coating's first test is to withstand handling ordinarily given line pipe in transit. Once it reaches Louisiana, it will be strung in the usual manner—just as though it were bare pipe.

The coated pipe will be bent in the usual manner and welded into the line. Of course, before the pipe is lowered into the ditch, it will be jeeped to determine how much damage was done in shipment and laying. The holidays will be repaired and the weld area coated (probably with tape).



H. C. Owens, technical director of Coast Paint & Lacquer Co. of Houston, Texas, holds a sample of the new coating, which has been in distilled water for six weeks. The only perceptible change was a slight loss in gloss.

Once the pipe is in the ground, company corrosion engineers will keep a close watch on the short line, and their findings may mean a great deal to the pipe line industry.

The corrosion department of the transmission company was instrumental in developing this new material. One of the tests that was most important from a corrosion standpoint, was conducted over a period of several months. Holidays were made in the coating deliberately to see how it would perform during actual cathodic protection. Normally, the process of cathodic protection builds up an alkalinity at the holiday. Some coatings fail because of this alkalinity and blister and peel off. The new coating, however, is not affected adversely by alkalinity and under test conditions the holidays have not enlarged.

Essentially, the new coating is a coal tar, epoxy resin mixture that polymerizes when mixed with an amine. Chemists have found that during this process the two basic materials establish cross-linkage. The resulting material is homogeneous and retains the best features of both ingredients.

For instance, carbon tetrachloride can be applied to the coating and no discoloration results. This indicates there is no free coal tar in the material.

Coal tar has been used in the pipe coating field for years and epoxy resin recently has become popular as an internal coating for both gas and sour crude lines. Also, the latter has proved effective in coating offshore drilling platforms. The epoxy has high mechanical strength and good elastic properties. Its dielectric strength is about 500 v per mil of thickness. One of coal tar's greatest virtues in the corrosion field is its resistance to moisture absorption.

According to laboratory tests, the new coating seems to retain the best features of both coatings. For instance, two sets of samples were subjected for six weeks to distilled ion free water—one of the hungriest solvents known—and also to intermittent boiling water. In both cases, the coating was undamaged except for a slight loss in gloss. The thickness loss and moisture absorption could not be measured.

Perhaps the greatest feature that the new coating absorbed from the parent epoxy base is the ability to bond with metal. Under test applications the new material was difficult to scratch with a knife. But even when the parent metal is reached, adjacent coating cannot be wedged off the metal.

But the characteristic that may mean most to the gas transmission industry, is the coating's resistance to plastic flow at elevated temperatures. In the laboratory tests there was no flow below 500° F and the coating did not start to blister until it reacned 550 F.

Samples that have been weathered for more than six months have shown no crazing or cracking—and epoxy resin coatings on offshore drilling platforms have withstood Gulf of Mexico weather in the splash zone, above the water and below the water without cracking. The only evidence of coating failure is a slight oxidation of the surface, but again the loss of thickness is too small to measure with practical accuracy.

The transmission company's position in this experiment is somewhat impartial with a look and see approach. The laboratory tests certainly justify a field test, and the rewards will be great if the coating proves successful.

One of the side effects that may come out of the project is that the coating may find its way into the water pipe line industry. An inexpensive coating similar to this may make it practicable to use on large diameter steel pipe for irrigating arid sections of the country.

Chances are that, like internal epoxy resin coating, the new material often will be applied at the pipe mill when it is used. Thus during shipment, storage, and field handling, the pipe will be protected. During the actual laying of the line, holidays will be repaired and the weld areas coated.

Actually, the coating, dubbed "Arocoat" by its makers, the Coast Paint & Lacquer Company of Houston, has been used on one pipe line to date. This was a short 4-in. screw line laid in the vicinity of Orange, Texas. In this instance, the line was coated with 20 mils of material with a glass fiber mesh wrapped in between coats. ★ ★ ★

New York City To Host 1956 NACE Meeting

Extensive program will have triple simultaneous sessions, over 60 papers, nearly 100 exhibitors

FEATURING the most extensive technical program in its history, the National Association of Corrosion Engineers' 12th Annual conference will be a beehive of activity during the week of March 12-16 in the Statler Hotel in New York City. Scheduled for the week-long meeting are 14 symposia and three discussion sessions, plus meetings of more than 60 NACE technical committees.

Pipe line corrosion problems will be featured at a number of the meeting sessions. Nine small discussion groups on pipe line corrosion will be one of the principal features of the annual meeting. These sessions will be held beginning at 2 p.m. on Wednesday, March 14.

A round table on "Pipe Line and Underground Corrosion" will be held on Friday, March 16, beginning at 9 a.m. Both the roundtable and the group discussion sessions will be informal and "off the record," giving pipeliners an opportunty to seek and exchange information on problems peculiar to their operations.

Chairmen of the group discussions are L. R. Sheppard of Shell Pipe Line Corporation and C. L. Woody of United Gas Corporation, Houston. Chairmen of the round table are L. B. Nelson of Shell Pipe Line Corporation and O. W. Wade of Transcontinental Gas Pipe Line Corporation, Houston.

Four papers on as many different subjects will be presented at the Pipe Line Symposium beginning at 9 a.m. on Wednesday, March 14.

Experiments Employing Diatomaceous Earth in Products Pipe Line Filtration, by Dr. Ivy M. Parker, Plantation Pipe Line Company, Atlanta, Georgia, will discuss the use of diatomaceous earth, injected into a flowing products stream, to aid in the removal of sediment that occurs in a well inhibited products line. Use of the earth as a filter aid has extended filter life, and the efficiency of dirt removal from line is considered excellent.

Gordon N. Scott, Los Angeles, California, will discuss *An Outline of a Physical Theory on Underground Corrosion,* in which the author, from a theoretical approach, attempts to account for the rate of accumulation of leaks on a pipe line. A display of evidence will be presented to support the theory.

B. J. Whitley, Jr., Tennessee Gas Transmission Company, Houston, will discuss *Cathodic Protection of Certain Semi-Marine Pipe Lines,* and H. W. Walquist, Ebasco Services, Inc., New York City, will present a paper on *Performance Tests on Pipe Line Coatings.*

Chairman of the symposium are L. G. Sharpe, Napko Paint and Varnish Company, Houston, and R. C. Martin, Plantation Pipe Line Company, Atlanta.

Other sessions of interest to pipeliners will include the Cathodic Protection Symposium at 9 a.m. Thursday, March 15, and the Protective Coatings Symposium at 2 p.m., Thursday.

A general round table meeting on corrosion will be held on Friday morning at 9 a.m., March 16. Audience participation will be featured in answering questions from the floor and those received by mail prior to the meeting.

Two educators with long records of activity in corrosion mitigation will receive the 1956 NACE awards. The 1956 Whitney Award will go to Dr. Norman Hackerman, professor of chemistry at the University of Texas. The 1956 Speller Award will be given to Dr. Mars G. Fontana, professor of metallurgical engineering, Ohio State University.

Nearly 100 companies will exhibit products or have booths at the meeting's exhibition hall in the Statler Hotel.

Social activities at the meeting will include the annual Fellowship Hour in the Penn Top Room following the close of technical meetings on Tuesday, and the annual banquet on Wednesday, also in the Penn Top Room of the Statler.

How Pipe Coatings Affect Complete Protection Programs

Austin S. Joy
Pipe Linings, Inc., Wilmington, California

EXCLUSIVE

A SEARCH OF TRADE LITERATURE, AN appointment with a protective coating salesman, or reference to existing standard specifications by the young engineer seeking a satisfactory method to protect only the outside of a new pipe line installation, is very likely to be a harassing experience.

The engineer will find his choice of available coating combinations for application by methods recommended or recognized by modifications of the standard specifications,[1] to be no less than 2000. Modifications of standards are recognized as improvements in protective coating quality, usefulness and coating longevity.

Should the engineer be seeking a satisfactory method to protect a pipe line internally as well as externally, he is faced with additional considerations. This phase of pipe line protection may be foreign to some oil pipe line engineers, but it is a principal concern of water works engineers,[2] or those oil pipe line engineers dealing with corrosively aggressive sour crudes,[3] or water flooding projects. In the water works field, consideration of internal and external protection of pipe lines is necessary from the smallest domestic water lines to pipe 17 ft in diameter, or larger.[4]

Internal and external protection of pipe lines is an important engineering accomplishment and deserves adequate attention by the pipe line design engineer.

2000 Coating Combinations

To derive the available protective coating systems for exterior protection that are allowed by standard specifications, or the recognized modifications of these standards, a brief review of materials and their use in essential. Table 1 is an effort to summarize variables of the coating materials that are in general use throughout the field of corrosion mitigation for the pipe line exterior.

A complete corrosion protection program for a pipe line will involve more variables than coating materials. Coating materials may be chosen with comparative ease. Today, an engineer may attempt to analyze coating materials, or pipe coating systems, using other than emperical methods.[5] The investigation by quantitative analysis on permeability and absorption properties of bituminous coatings was reported by Anderson and Wright[6] and concluded "the amount of water that may become established within coatings that are properly formulated never reaches a concentration sufficiently high to satisfy the conditions requisite for electrochemical corrosion." Beckman, and others,[7] made a quantitative analysis of factors that may influence corrosion of metal surfaces protected by bituminous coatings. They concluded "imperfections in the coating is a dominant cause of occasional failure to protect against corrosion."

The engineer can expand upon quantitative analysis, introducing environment, construction conditions, economics, cathodic protection, and many, many other factors that for a better term may be known as "variables." Variables will indicate coating construction, or a more recently recognized term, coating systems. In Table 2 is an outline of coating systems that are in use today.

Selection of a Suitable Exterior Coating System

Selection of the one protective coating system for the outside of a steel pipe line requires knowledge of environment to be expected where the pipe line is to be installed. To secure the appropriate information about environment is a gigantic task. Many pipe lines have been built, and, therefore, it holds that many pipe line design engineers have been faced with the necessity of selecting a protective

TABLE 1. Variables of Protective Coating Materials.

I. **Protective Bitumen**
- A. Asphalt — *No less that 11 characteristic materials*
- B. Coal Tar — *No less than 8 characteristic materials*

II. **Wrappers**
- A. Bitumen Saturated Felts, vary as to
  - *1. Weight*
  - *2. Saturant*
  - *3. Per cent Saturant*
  - *4. Base Materials*
- B. Glass Inner Wraps, vary as to
  - *1. Thickness*
  - *2. Binder*
  - *3. Configuration*
- C. Glass Outer Wraps, vary as to
  - *1. Thickness*
  - *2. Saturant*
  - *3. Configuration*
  - *4. Surface*
- D. Cellophane type, vary as to
  - *1. Thickness*
  - *2. Chemical Base*
- E. Kraft, vary as to
  - *1. Weight per ream*
  - *2. Smooth or creped*
- F. Generally not for use in conjunction with added bitumens
  1. Pressure Sensitive Tapes, vary as to
     - *a. Chemical Base*
     - *b. Adhesive*
     - *c. Thickness*
  2. Bitumen Saturated Tapes, vary as to
     - *a. Heat required upon application*
     - *b. Bitumen*
     - *c. Base Tape*
       1. Material
       2. Configuration

III. **Seamless Applied Mastics,** vary as to
- *1. Bitumen softening point*
- *2. Thickness*
- *3. Per cent bitumen*

IV. **Metal Coatings**

V. **Cement Mortar,** vary as to
- *1. Thickness*
- *2. Reinforcement*
- *3. Base materials*

coating. In many cases, the methods used by the design engineer are his own.

It is not the author's intent to in any way criticize a pipe line design engineer's method of choice.

Instead, it is to provide an outline whereby such a choice and the resultant specifications provided by the engineer, are complete and with sufficient detail that upon purchase and application to the pipe line, the design engineer actually secures the protective coating he has so laboriously selected.

Where steel pipe is to be laid under conditions ordinarily found in oil, gas, water, or miscellaneous transmission or distribution systems, the exterior surface of the pipe may be cleaned, primed, and coated with an appropriate bituminous protective coating system. The terms the engineer uses to describe cleaning, priming, and coating, must be chosen accurately and with extreme care.

There is one qualitative truth regarding bituminous coatings that apparently must be recognized as fact, for it is so often mentioned in trade literature and is so often used in practical demonstration, "Bituminous coatings greatly retard the loss of metal to which they are applied. Their effectiveness is roughly proportional to their thickness."[8] This statement reflects the engineering principle for multi-coat wrappings and thick asphalt mastics.

Considerations for the choice of a coating system have been listed in trade literature. These considerations all seem to originate from the desire to "insulate" the pipe line. Ewing,[9] Uhlig,[10] Speller,[11] and other engineers all appear to agree with Logan[8] who concluded, after a ten-year study of coatings installed at 16 highly corrosive sites widely separated throughout the United States, that a coating selected by the engineer should conform in general to this outline:

1. **Bitumen — a permanent electric insulator.**
2. **Shields and Reinforcements —**
   a. Be permanent
   b. Ridged enough to distribute soil stress
   c. Designed to prevent flow of bitumen
3. **Finished coating — thickness an important factor.**
4. **Finished coating—rigid enough to withstand soil stress.**
5. **Finished coating—elastic enough to withstand changes in temperature.**
6. **Finished coating — economically sound.**

TABLE 2. Bituminous coating systems.

I.	**Dipping — Single**
	Vertical
	Horizontal
II.	**Dipping — Double**
	Vertical
	Horizontal
III.	**Dipping — Externally Wrapped**
	Vertical
	Horizontal
	Wrapper
IV	**Single Coat-Single Wrap**
	Primer
	Hot application
	Wrapper
	Hot application
V.	**Double Coat-Single Wrap**
	Primer
	Hot application
	Hot application
	Wrapper
	OR
	Primer
	Hot Application
	Wrapper
VI.	**Single Coat-Double Wrap**
	Primer
	Hot application
	Wrapper
	Wrapper
VII.	**Double Coat-Double Wrap**
	Primer
	Hot application
	Wrapper
	Hot application
	Wrapper
	OR
	Primer
	Hot application
	Hot application
	Wrapper
	Wrapper
VIII.	**Double Coat-Triple Wrap**
	Primer
	Hot application
	Wrapper
	Wrapper
	Hot application
	Wrapper
IX.	**Triple Coat-Double Wrap**
	Primer
	Hot application
	Wrapper
	Hot application
	Wrapper
	Hot application
	OR
	Primer
	Hot application
	Hot application
	Wrapper
	Hot application
	Wrapper
X.	**Triple Coat-Triple Wrap**
	Primer
	Hot application
	Wrapper
	Hot application
	Wrapper
	Hot application
	Wrapper
XI.	**Extruded Mastic**
	Primer
	Mastic

The Author

Austin S. Joy, sales manager of Pipe Linings, Inc., was graduated from the University of California at Berkeley with a BS degree in forestry in 19[illegible]. Since his graduation, with the exception of a period of two years, he has been identified with pipe coating and wrapping services. He has been active in the National Association of Corrosion Engineers, American Water Works Association, Pacific Coast Gas Association, and American Petroleum Institute. His present work with Pipe Linings, Inc., involves the sale and promotion of pipe coating techniques, both internally and externally.

The engineer's specification for a protective coating not only provides one of the basic "first costs" for the pipe line installation, but it also reflects his complete knowledge and plan for the cost of the long range corrosion prevention program.[12]

Writing any specification, the engineer is considered an expert in his field. It is upon his expert opinion the grade of steel required to stand the working pressure is selected. It is upon the engineer's expert opinion the size and wall thickness of pipe is selected. The big difference between these factors of pipe line design and protective coating design is in the formulas available from standard texts and reference material.

Yet no less important, in the life span of all pipe lines' economic operation, is the consideration the engineer must incorporate in his design of a pipe protective coating.

A recent specification that came to the author's attention read,

"Before application of the exterior asphalt coating, the pipe shall be thoroughly cleaned and coated with a suitable asphaltic primer . . . it shall receive two applications of the best grade air-blown California Asphalt Pipe Dip . . . to form a coating on the pipe not less than 1/32-inch in thickness." ". . . it shall be spirally wrapped with a 40-lb felt. . . . When dry, the coating shall be thoroughly tested . . ."

There is a series of important questions that immediately come to mind upon study of a specification of this kind.

1. **What is thoroughly clean?** Wipe the surface with a soft cloth or remove all oil, grease and mill scale by steel grit blasting, are probably the two extreme answers that may be considered as rational.
2. **What is a suitable asphaltic primer?** The manufacturers of primer, either coal tar or asphalt, have provided complete and detailed primer specifications. The engineer should not leave to opinion that which is "suitable."
3. **What is the "best grade" of anything?** Again let the engineer specify the "best" product by reference to existing standards of either the coal tar or the asphalt industry.
4. **Is "not less than 1/32-inch in thickness" an adequately delineated specification?** Here is a clear case of opinion, those studying and reporting their results on protective value of pipe coatings firmly believe thickness is an important factor.
5. **What 40 lb felt?** In this instance, as has been pointed out, there are at least two basic materials of which felt is manufactured, several surface preparations, more than one kind of saturant, more than a few degrees of saturation. Quantitative values beyond weight are requisite to clearly establish the pipe line design engineers desire for the correct felt he expects to meet the requirements imposed by a specific environment.
6. **"When dry" — what is actually meant by this term?** Is it simply less than a satisfactory choice of words, or does the engineer mean immediately after the pipe coating has cooled? It is essential a point of acceptance be established in the pipe line design engineer's specifications in order to establish a point for inspection and test of pipe coating integrity.

There are those specifications for applying protective coating to pipe lines that refer to the well known "standards" that are listed by reference in the introduction of this article. These "standard" specifications are a guide! The pipe line design engineer is called upon to make the guide specifications applicable to his particular corrosive and operating condition.

It should be noted the "standards" require the detail of any modification the engineer feels is required, single coat, multi-coat, mastic, the exact specification of protective bitumen, or wrapper.

The materials to be used should be specified by designating within reasonable limits, physical characteristics as outlined by the manufacturers of those materials. In general, Table 3 gives the wide range of bitumen available for coating pipe. Most bituminous pipe coating materials can be manufactured within this range. There is a specific material that should be chosen from those commercially available for a specific job.

The wide range of available hot applied pipe coating bitumens is an important engineer's tool for satisfactory application of a protective coating. This choice must be used wisely. Each coating that is designed by the pipe line design engineer is a combination of the correct bitumen and reinforcement shield or aggregate.

The most complete and detailed coating specifications, plus the best protective coating materials may be furnished, but their effectiveness and results depend upon the supervision, inspection and control of the application by experienced, qualified and dependable personnel.[13]

TABLE 3. General Characteristics of Commercially Available Hot Applied Pipe Coating Bitumens.

	Asphalt		Coal Tar	
Softening Point F	180	260	160	235
Penetration at 77 F	6—	40	0	20
Filler — Per cent	0	40	20	40
Specific Gravity	1.02	1.12	1.35	1.65

Application of Protective Coating

Application to the pipe surface clearly indicates another variable to be added when considering the multiplicity of pipe coatings available. The main differences can be summarized as "Point of Application:"

1. Central plant
2. Portable plant
3. Over-the-trench
4. By hand

Each has its distinct advantages and likewise its disadvantages, that are no doubt obvious to the experienced design engineer when he is considering a specific project of pipe line construction.

Common to all methods of pipe coating application, after the selection of the coating system, is the pipe surface preparation. **Coating should be applied to the pipe, not to loose dirt, mill scale, oil, grease and rust that accumulate on the pipe surface before it is to be coated.**

Surface preparation is the foundation upon which the value of protection a pipe coating system selected by the design engineer depends. Steel grit blasting equipment, mechanically propelling the properly selected size of grit against the pipe surface, to no surface preparation at all, are the extremes from which engineers may select a method for surface preparation.

Surface Preparation. Proper surface preparation has been studied in detail and is reported by the experts in this field. A summary here is unnecessary, as reference to the standards listed in the introductory remarks will provide the design engineer with details of most available accepted methods. Study is continuing in most technical associations.[14]

The National Association of Corrosion Engineers, Unit Committee T-6G, Surface Preparation for Organic Coatings, S. E. Jack, chairman; and Unit Committee T-6R, Protective Coatings Research, R. H. Steiner, chairman, should provide additional standards for pipe surface preparation techniques.

Primer. The application of primer to the prepared pipe surface may be by spray, pouring and wiping, or brushing. The primer may be wet or dry upon the application of the hot bitumen. Experience and knowledge based upon fact, not conjecture, should dictate the engineers' choice in selecting a protective coating — priming method.

The prime coat, next to surface preparation, is the foundation upon which rests the value to be realized from a protective coating. It is not sufficient to say the primer shall be compatable with the next layer of hot applied bitumen. The engineer should specify that which, in his studied opinion, will best serve his purpose of overall pipe protection design.

Hot Application. The application of bitumen to the prepared and primed surface should be detailed in a specification. The design engineer should insure proper thickness, coverage, and preserve the physical characteristics of the bitumen that, in his opinion, will best serve his long range pipe protection purpose. Application of subsequent layers of bitumen, over imbedded wrappers, or over the surface of wrappers that may be acting as shields or reinforcements, should be detailed with the design purpose in mind.

In the case of extruded asphalt mastic coatings, precaution should be

exercised to insure that a dense, impervious, essentially voidless mixture of the proper grade of asphalt binder, mineral aggregate and mineral filler (which may include asbestos fiber) is applied.

Wrappers. The purpose of the wrapping specified by the design engineer is well known to him. He should write his specification with the detail to protect that purpose. **Wrinkles, voids in the bond to bitumen, sags, amount of lap, all tend to weaken the protective value to be attained when properly selected wrappers are used.** The relative position with reference to the pipe surface of an imbedded wrapper is important to the protective value where these wrappers are used.

Exterior wrappers, those appearing on the extreme outside of pipe coating systems, are sufficiently vulnerable to abrasion and mechanical damage during construction or soil stress after installation, that the engineer should insure adherence to his express purpose by appropriate detail in his specifications.

Cathodic Protection

The addition of cathodic protection as part of a long range plan of corrosion prevention may be an important part of the selection of the pipe coating system.

Cathodic protection may be an expensive expedient due to the selection of a less than satisfactory coating.[15] "Cathodic protection is the use of an impressed current to prevent, or to reduce the rate of corrosion of a metal in an electrolyte (environment), by making the metal the cathode for the impressed current," according to John M. Pearson, writing for H. H. Uhlig in the *Corrosion Handbook*.[10] Stray currents from cathodic protection installations should be controlled to prevent possible damage to contiguous structures or poorer pipe coatings.

The protective coating system selected affects the current requirement for supplemental cathodic protection he may wish to design as part of his corrosion prevention program. The engineer's choice of a protective coating system may be the dividing line between economic cathodic protection or prohibitive operation expense.[16]

It has been variously pointed out that the cost of cathodic protection of a pipe line may vary from $.75 or more per foot capital expense, plus $.10 or more per foot per year maintenance and operation expense for a bare pipeline, to less than $.02 per foot for capital expense, plus $.001 or less per foot per year maintenance and operation expense for a well coated pipe line of the same size, in the same environment.[17]

Conclusion

From the multiplicity of pipe coatings available, a coating system may be selected for the particular project that is to be built. Corrosion engineers and management alike agree effective corrosion prevention in industry is economic and necessary, and tends to:

1. **Reduce operating and maintenance expense.**
2. **Avoid contamination of the oil, gas or water being transported.**
3. **Assure employee and public safety.**
4. **Reduce investment losses.**
5. **Lessen waste of product.**
6. **Minimize service interruptions.**
7. **Reduce damage claims.**
8. **Create better and safer service.**
9. **Result in an important improvement in public relations.**

Some industries have corrosion problems and can shield them from public view, or tolerate them in other ways. Pipe lines extend from the thinly populated areas of production to the most thickly populated metropolitan areas.

It is obvious that such a system must be designed, installed, maintained, and operated with all due regard to economic corrosion prevention that will satisfactorily perform over a long range period.

Corrosion engineers are not yet dealing in an exact science. The preventative measures that are practiced are fraught with opinion. Misapplication of techniques and materials have condemned themselves without proper trial. The inexperienced engineer is writing and rewriting from his "bookshelf of standard specifications" and not taking advantage of proven techniques and practices.

The author thinks of Dr. Frank N. Speller, for many years director of the Metallurgical Department of the National Tube Company, as the "Dean of Corrosion Engineers." Dr. Speller wrote a book in 1926, *"Corrosion, Causes and Prevention, an Engineering Problem."*[11]

So many design engineers forget the full title to Dr. Speller's book — **"an engineering problem."**

It is imperative that a pipe coating system be designed on engineering prinicples and not be considered a necessary evil to be skimped or taken for granted! Present day protective coating systems to be effective, require the attention of pipe line design engineers and the control of application by adequately written specifications and inspection.

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* * *

Main line pumping units at the Interstate Oil Pipe Line Company Finney Station near Shreveport, Louisiana, gleam in the sunlight at their outdoor location. All of the weatherproof components in each of the three pumping units are factory-standard. The only additions to factory equipment are the weatherproof sheet metal safety covers over the shaft couplings and rodent screens over air vents of motor housing.

P 615.51

CORROSION FEATURE

CASE HISTORY: Outdoor Pumping Equipment

Is "Special" Protection Really Necessary

N. M. Lytle
Master Mechanic,
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Shreveport, Louisiana

Interstate Oil Pipe Line Company finds factory built "optional" equipment combined with good operating practices gives good results with minimum costs

EXCLUSIVE

THE TREND IN THE PIPE LINE INDUSTRY in recent years toward outdoor pumping installations has brought about many new problems. One of the most serious is protection of equipment from the weather.

Some members of the industry have sought special types of protection, but others are using factory-standard weatherproof equipment and a sound paint and operating maintenance program.

Interstate Oil Pipe Line Company, operating under climatic conditions ranging from salty and humid coastal Louisiana to the northern winters of Montana, is following a traditional pipe line approach to the weather protection problem. This is graphically illustrated by Interstate's Finney Station, built about two years ago near Shreveport, Louisiana.

Finney Station is one of Interstate's largest and most modern installations. Pumping equipment includes three two-stage centrifugal main line pumps, each driven by a 1500-hp electric motor, and two horizontal centrifugal booster pumps, each powered by an electric motor of 100-hp. These pumps, motors, and much of the station's accessory equipment are all installed out in the open.

The pumps, insofar as weatherproof-

ing is concerned, are factory standard, with covers over seals. The same model pumps are used at enclosed stations. No special alterations were made for weatherproofing, though pump impellers have been altered to meet line operating needs.

The 1500-hp electric motors at Finney are also factory-standard units, each equipped with standard weatherproof housings supplied by the manufacturer. The only alternation made in the standard housings was the addition of factory-standard rodent screens to the air vents. The manufacturer lists the screens as optional equipment, and were added to keep birds, rodents, and large insects out of the motors.

Protection of motor windings is built into the standard outdoor motor as purchased from the manufacturer. Designed for outdoor use, these motors have as standard equipment electric heaters to prevent moisture from collecting inside the motor or on the windings.

The only other addition to factory-standard equipment on the pump installations at Finney has been the fabrication of sheet metal safety covers over the shaft couplings between the pumps and motors. Such covers are standard with Interstate as a safety practice, but at Finney they also serve as weather shields for the shaft coupling.

The same maximum use of factory-standard weatherproof equipment is true of the components of the booster pump installations at Finney, and no further alterations have been deemed necessary to date. Such instrumentation and switch gear as was necessary to install at the main line and booster pump locations is also of factory-standard outdoor design, and was installed in weatherproof metal cabinets as a matter of standard practice.

Other outdoor equipment at Finney, such as the tank mixer motors, truck unloading rack motors, the sump pump, motor operated valves, starters, switches and junction boxes are all standard explosion-proof equipment, with no additional special modifications.

While the pumps, motors, and other outdoor equipment at Finney Station are completely exposed to sun, wind, rain, and ice, no special protective paints have been employed on the outdoor equipment. It is all painted with standard outdoor aluminum paint, and maintenance is performed whenever the equipment needs it.

In repainting, standard outside aluminum paint has been applied directly over the manufacturer's finish, or over previous coats, after the surfaces have been wiped clean. Experience to date has shown that the standard paint materials used have not required appreciably more maintenance on outside installations than would have been needed for the same equipment under shelter.

Grassy marshlands spread as far as the eye can see around the Interstate Oil Pipe Line Company Esso Station in the Delta Farms field near Delta Farms, Louisiana. The station is comprised of two field pumping units mounted in the open on a creosote piling pier.

Although Finney Station is a large scale example of the use of standard weatherproof components for a major outdoor installation, the same practice has been followed throughout Interstate's operations, down to the smallest field pumping unit. More than 1000 field pumping units in four general sizes are used in Interstate's six-state operating area. All are fabricated to company specifications on skid mounts from standard, weatherproof components.

Nearly 90 per cent of these smaller pump stations or field pumping units are installed in the open. The remainder, mostly older installations, are in enclosed stations or under shed roofs. None of them, however, have undergone any special alterations to make the components more weatherproof than they were when received from the manufacturer in standard form.

Interstate's field units, however, are equipped with factory-standard "optional" equipment such as *exhaust pipe weather flaps* and *weatherproof sheet metal safety covers* for their Vee-belt drives. New units are also being ordered with such additional factory "extras" as *dust covers* for reciprocating pump rods and *drip pans* under the pump glands. The dust covers protect the polished pump rods from rain, salt water spray, and trash. The drip pans prevent leakage from glands from spilling onto the pump location.

Interstate installs new field pump units as they are received from the factory, with the original finish applied by the manufacturer. When repainting becomes necessary, however, standard outdoor enamel in the colors prescribed by the company's color standards is applied directly over the previous surface coating, after cleaning the surfaces. Inspection of equipment determines the need for repainting, for protection, and for neatness and appearance of the units.

The life of paint finishes on outdoor pumping equipment varies with location. Interstate has found that units near salt water or in areas of "sour crude" production will require more paint maintenance than units in other areas. The only additional precaution in salt or hydrogen sulfide-laden atmospheres, however, is more frequent inspection and repainting.

While Interstate makes maximum use of weatherproof components and sound paint maintenance practices as the mainstay of its weather protection program, with a minimum alteration of factory-standard equipment, special alterations for improved operating maintenance are far more common. Such alterations are undertaken for the prime purpose of keeping "down-time" of field equipment to an absolute minimum.

In areas where natural gas is available as fuel, for instance, it is used. Where there is sufficient pressure, air-gas starters are installed on field pumping units to eliminate possible battery, electric starter and generator troubles. Antifreeze is used, in accordance with the manufacturer's recommendations, for all outside and many inside installations. Where extremely low temperatures are encountered, lighter lube oils are used in the pumping unit engines during the colder months.

All Interstate field pumping instal-

PARSONS 150 TRENCHLINER®

holds accurate grade

Hydraulic power raises, lowers, tilts the digging wheel

Hydraulic wheel-hoist control on Parsons 150 heavy-duty Trenchliner maintains close grade tolerance in toughest digging — an important advantage on cross-country transmission lines, feeder and gathering lines. Hydraulic ram on vertical mast raises and lowers the digging wheel with fractional-inch accuracy. A separate hydraulic ram tilts the mast — balances weight of wheel forward for traveling or trailer-loading.

Heavy-duty digging wheel takes either square or round-bottom, cast-steel buckets, with solid or tine backs. For digging dry or wet materials, the quick-change buckets have gumbo lips, or self-sharpening, reversible "Tap-In" teeth. Belt conveyor, 24 inches wide, is shiftable, reversible, discharges spoil to either side.

Standard tractor crawlers on this Parsons 150 Trenchliner have 16-inch treads, grouser-type shoes — provide plenty of sure-footed traction for cross-country work. Yet, ground-bearing pressure is low, only 6.3 pounds PSI. For power, you have a choice of standard-make gas or diesel engine. Find out how this heavy-duty 150 Trenchliner fits into your pipeline spread, for main-line trenching — or as an auxiliary unit for digging laterals and gathering lines. Get in touch with your Parsons distributor or write us for bulletin.

Digs up to 25 ft. per minute—16 to 26 in. wide—5¾ ft. deep.

Send to: PARSONS COMPANY, Newton, Iowa
(Koehring Subsidiary)
for bulletin on 150 wheel-type Trenchliner

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8 other sizes of Parsons Trenchliners include wheel and ladder-types, full crawler mounted . . . and a rubber-tired Trenchmobile.®

lations are equipped with automatic safeguards to shut down engines when lube oil pressure is low, or when coolant temperature is high. Some units are also equipped with timeclocks for automatic shutdown after a predetermined volume of oil has been pumped, which allows the gager to leave the units after putting them into operation.

Interstate's multi-unit field installations are set up with parallel units standing side by side along a common base line. Each unit, however, is set at a 45-deg angle to the base line. This angled arrangement keeps hot air from one engine's radiator from blowing over another one, thereby contributing to cooler engine operation.

In certain sour crude areas, Interstate employs one additional protective measure on its equipment. Radiators of engines in such areas are coated with a special preparation to prevent external corrosion.

A more recent maintenance development has been the conversion of some field units to "long-run" operation — equipping them for operating over long periods with a minimum of downtime maintenance. A "pilot" long-run installation is now in its second-six month period of operation without a maintenance shut down.

Special equipment used to convert field pumping units to long-run operation includes:

Special greases and greasing equipment for clutches and fans, eliminating the need for grease lubrication by field personnel;

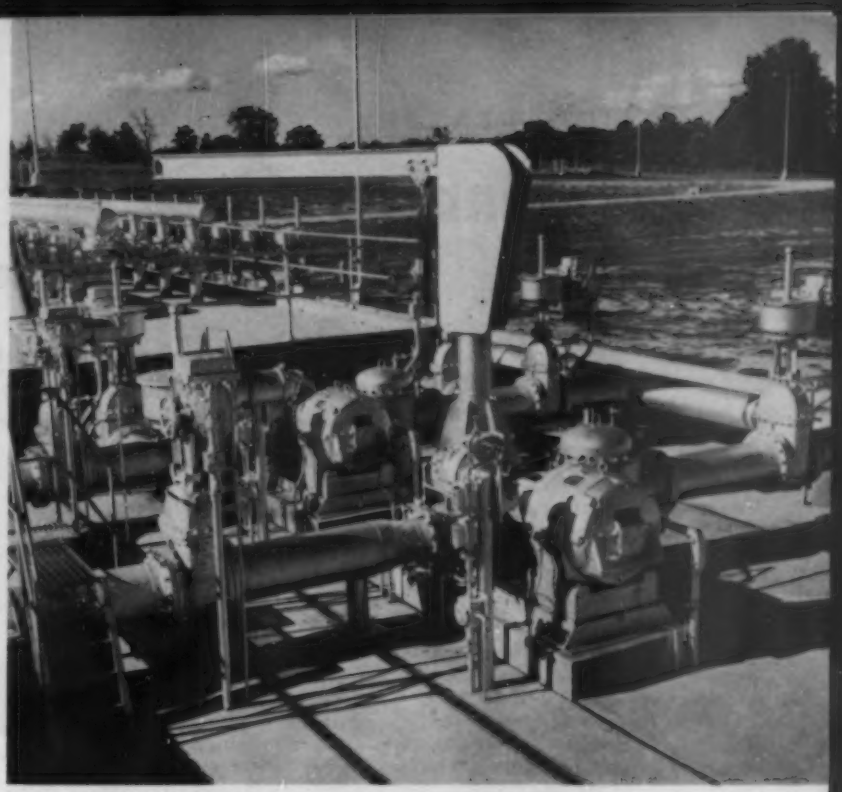
Lube oil regulators and an extra lube oil supply to maintain a pre-selected oil level in the engine crankcase, adoption of a lower operating oil level to reduce the amount of oil blown out through the exhaust and to minimize the carbon formation in combustion chambers;

Special platinum-point spark plugs and platinum magneto points;

Oversize oil filters;

Scrubbers and volume tanks to protect carburetors and to reduce carburetor maintenance requirements; and **condensers** to extract water from the engine exhaust for the radiator. Radiators supplied from exhaust condensers are protected by using an inhibitor to prevent the condensed water from causing internal corrosion.

Although vastly different in design and function, Interstate's electric-powered, outdoor Finney Station and a pilot long-run conversion of a gas-fueled field pumping unit both illustrate what the company is doing in the field of weather protection of equipment using standard factory components, and a sound paint and operating maintenance program. * *



A detail view of the booster pump installation at Finney Station shows the two 100-horsepower electric motors and the horizontally mounted centrifugal booster pumps. The motors are factory-standard weatherproof, but not explosion-proof, and have had no additional weatherproofing.

A closeup view of one of the pumping units at Finney Station shows details of the factory-standard outdoor weatherproof housing for the 1500-horsepower electric motor which powers the centrifugal pump. The rodent screen over the air vents, factory-standard optional equipment, and the sheet metal safety guard over the shaft coupling are the only additions to original equipment.

P 615.635.

STRAY CURRENTS:
Big headache for corrosion engineers

Dean O. Griffith
Area Corrosion Engineer, Shell Pipe Line Corporation, Houston, Texas

As more and more pipe lines are laid, cathodic protection interference problems increase; proper use of today's protective coatings, cathodic protection units, and good practices can reduce these problems considerably

WHEN SIR HUMPHREY DAVY DISCOVERED the principle of cathodic protection in 1824, he was searching for a better method of preventing corrosion on the copper hulls of English ships. Today, over a century later, corrosion engineers are still searching for better methods of preventing electrolysis corrosion damage caused by straying currents from an ever-increasing number of cathodic protection units. Most of these units are installed to mitigate pipe line corrosion by the best known applications of the Davy Principle.

Today's Problem . . .

Residential and industrial development along pipe line rights-of-way, with corresponding additions of underground utility lines and metal structures, are constantly increasing the difficulty of maintaining existing cathodic protection systems.

Installing cross bonds to prevent damage as new lines enter the same right-of-way with an existing line under protection results in lowering the protection on the protected line, thereby posing a serious problem to its owner.

The most practical solutions to this problem seem to be either costly excavation of the pipe for new coating application or the addition of cathodic protection units, which are many times more costly than the original installations due to the increased costs of materials, labor, and property. Time consumed by key personnel for joint tests, operational adjustments, and maintenance of bonds is also very expensive.

. . . and Its Cause

Early cathodic protection systems, which were placed in operation on bare or partially coated systems, have proved the value of the Davy Principle so well that industry is almost universally relying on its application to cut down its billion dollar per year loss from underground corrosion.

In these installations it was necessary to employ large current densities, which materially affected soil areas many times greater than the right-of-way. Most of these soil areas contained no other buried metallic structures and interference problems were nonexistent.

Such early systems were usually justified economically on a corrective basis and depended for the most part, solely on electrical current for protection of the buried metal. As a result the protection systems were usually elaborate and quite expensive. Later systems installed in the same right-of-way were usually designed to minimize the interference problem by the use of coatings. The use of coatings usually eliminated the possibility of using the more economical joint cathodic protection system.

This may be better understood by realizing that most of the early systems were designed for maximum protection to the existing piping system without regard to future installations on the same right-of-way.

Most cathodic protection systems that were installed at later dates, incorporated the use of the best available coatings, as the cost of initial permanent coatings was much less than the continuous cost of electrical energy required for the protection of large areas of bare pipe metal.

When systems were designed with high quality coatings, however, smaller protection currents were required and actual interference currents became too small to be easily or accurately determined. Thus, the prorated costs of a joint system were impractical to determine and in many instances cathodic mitigation levels maintained on the early system were not high enough to provide adequate protection levels on the newer system.

Little Anode, Big Cathode . . .

Ironically, the addition of an excellent insulating coating on the pipe without obtaining the impossible perfect coating causes a violation of a most basic rule of corrosion prevention design by connecting a very small anode to an extremely large cathode of pipe. This condition results in a much greater point corrosion rate (faster penetration) on the pipe (Fig. 1). Such coatings, therefore, must be supplemented with small cathodic protection currents, which must be constantly maintained.

The current provides cathodic protection to small areas of exposed metal at coating imperfections and also provides a convenient method of checking additional coating failures using soil-to-pipe potential measurements. This check method increases in accuracy as the current requirements decrease with improved coatings. The check method can be compared to an "Alarm System" because any sizable damage inflected on the coating at any point in the system will result in a large reduction of cathodic protection potential on the remainder of the system.

. . . Causes Trouble Quickly

To better illustrate the critical nature of this small current, visualize an almost perfectly insulated pipe line coated in such a manner that only a ¼-in. diameter flaw (anode) is left in the coating. This small anode is thereby connected to an infinite cathode.

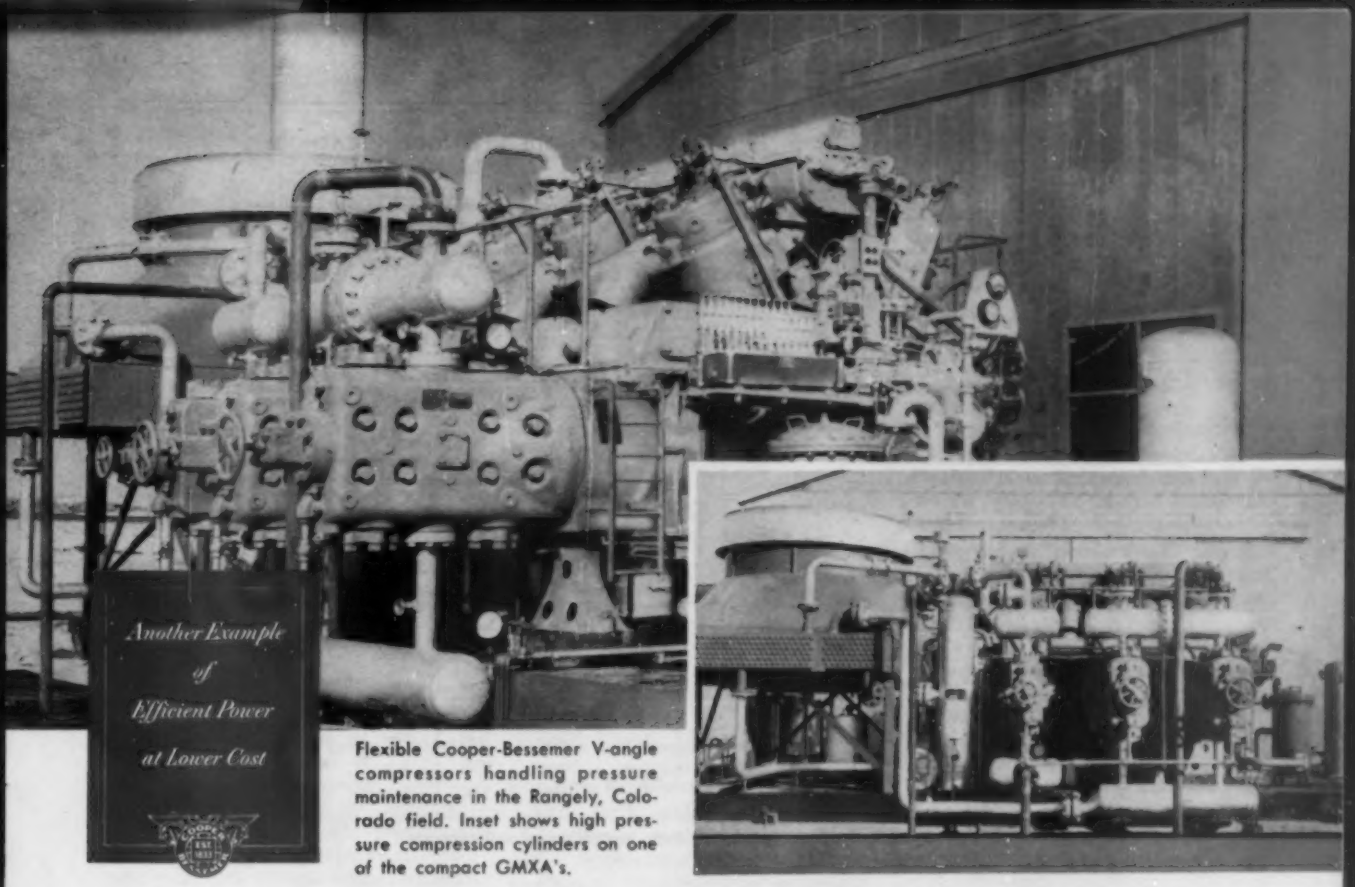
Using the rate of approximately 20 lb of metal loss per year per ampere of current, simple calculations will show that even 1 milliampere of current flowing from this small anode would cause a penetration of the pipe in less than three months.

It is readily seen, therefore, that the installation of additional lines in or across rights-of-way having high cathodic protection soil currents constantly increases the likelihood of damage to such new lines.

Modern Practices

With the present trend in industry toward greater throughputs with large-diameter, thin-walled, high-strength pipe lines constructed of pre-stressed steel, little or no initial corrosion can be tolerated.

EXCLUSIVE



Flexible Cooper-Bessemer V-angle compressors handling pressure maintenance in the Rangely, Colorado field. Inset shows high pressure compression cylinders on one of the compact GMXA's.

• How **PACKAGED COOPER-BESSEMERS** "keep pressure up, costs down" in the Rangely Field

HERE, eleven Cooper-Bessemer GMX and GMXA compressor units are keeping pressure maintenance *and costs* "well under control."

Located in four different stations, these 330 and 375 hp Cooper-Bessemer compressors handle pressure maintenance with minimum attention and maximum operating effectiveness.

Designed especially for this type of field service, these tested Cooper-Bessemers save time and installation cost because they're packaged and skid mounted . . . . fully assembled and ready to go to work in a hurry.

If field requirements should change, these compact units can be transported by either truck trailer or railway flat car. Except for the concrete slab foundation and a minimum of connection piping, the entire installation can be quickly moved and re-installed for economical and dependable service in another location.

For complete details on these and other heavy-duty Cooper-Bessemer V-angle compressors, ranging in horsepower from 200 to 3000, consult the nearest Cooper-Bessemer office listed below.

Tulsa Shreveport St. Louis Los Angeles Chicago
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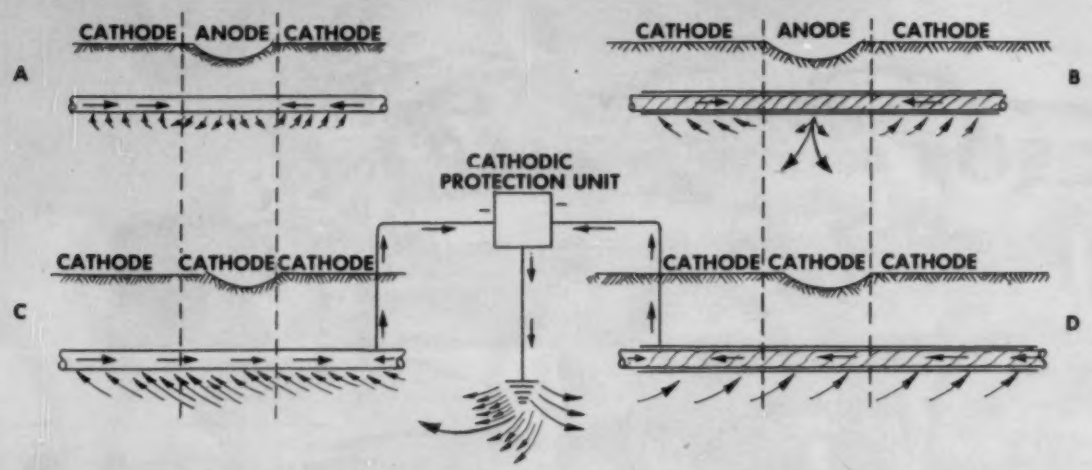


Condition	Coating type	Cathodic protection	Corrosion type	Metal loss	Service life	Cathode soil area				Anode soil area			
						Soil res.	Chem. conc.	Cathode anode	Current density	Soil res.	Chem. conc.	Anode cathode	Current density
A	None	None	General	Large	Long	High	Low	Average	High	Low	High	Average	High
B	Good	None	Pitting	Small	Short	High	Low	Large	Low	Low	High	Small	High
C	None	Applied	None	None	Infinite	High	Low	Average	High	Low	High	Average	High
D	Good	Applied	None	None	Infinite	High	Low	Large	Low	Low	High	Small	Low

FIG. 1. Effect of coatings and cathodic protection on soil currents.

Most new systems must therefore be maintained on a strictly preventive basis rather than the early corrective mitigation basis. Increased metropolitan development has resulted in greater right-of-way costs, forcing many owners to share small common rights-of-way.

Maintenance of such new lines is so critical that most owners utilize all available past corrosion data concerning the rights-of-way that the system is to traverse and design their lines for minimum corrosion damage. Naturally, the newer systems are designed to include the latest developed coating, thereby minimizing the amount of cathodic protection current required.

When a joint cathodic protection system is considered, the cost of energy required for protection of the new system with separate cathodic protection units is usually small compared to costs of joint operations and joint maintenance.

In instances where the new system could be protected from existing units along the line the cost of energy transferred would be dwarfed by the accounting and contract cost.

An example of independent cathodic protection systems resulting from the aforementioned condition is shown in Fig. 2.

Line (1) was coated when it was laid with dresser-couplings at joint ends, which served as insulators, therefore, soil concentration cells were restricted and long-line currents were eliminated. Its rate of initial corrosion penetration (22 years) therefore could be attributed to these factors.

Line (2) was welded at its joint ends and left uncoated. This continuous line was affected by long-line currents set up by combinations of large and small concentration cells in the soil, which resulted in a faster initial penetration rate (9 years).

Line (3), although it was coated with the best original coating, had the fastest penetration rate (3 years) due to the small anode-large cathode condition shown in Fig. 1. Reconditioning and coating operations performed on Line 2 resulted in a more effective coating, which required less current for protection than either of the other two lines.

It will be interesting to note that practices considered good in cathodic protection design were used by each individual owner as his line was protected; however, joint cathodic protection systems were never considered desirable.

Protective Methods

A perfect coating would offer complete protection to the buried pipe and eliminate all interference problems, and it would be logical to assume that most corrosion engineers are directing their search in that direction.

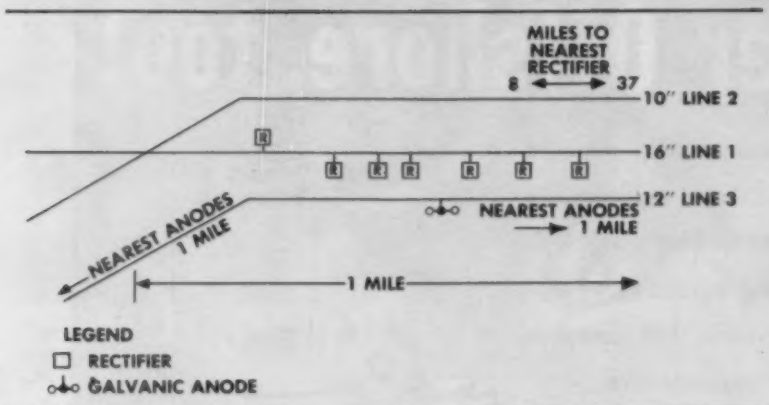
Perfection, however, is considered impossible to attain and the combination of coatings with applied protection currents appears to be the only present solution to the problem.

Coatings, being the cheaper of the two components, should follow past trends, and continue to improve with time. This being the case, it would also be logical to assume that in a few years the present interference problems will only be magnified by a wider variation of coatings, unless corrosion engineers allow enough flexibility in design of their protection system to minimize interference under the most extreme conditions.

Such design technique, to be effec-

The Author

Dean O. Griffith, area corrosion engineer for Shell Pipe Line Corporation, Houston, Texas, attended Kilgore College and Texas A&M College, where he majored in chemical engineering. Shortly after he joined Shell Pipe Line in 1942, he served three years in the armed service. His assignments with Shell cover all phases of corrosion work connected with construction and maintenance of pipe lines. He is an active member of the National Association of Corrosion Engineers.



No. Line Size	1 16-in. Diameter	2 10-in. Diameter	3 12-in. Diameter
Installation date	1928	1931	14
Joint coupling	Dresser	Acetylene weld	Electric weld
Original coating	Asphalt emulsion	None	Asphalt and asbestos wrap
Application method	Hand	None	Machine
First pipe penetration	1950	1937	1944
Line reconditioned	None	1946	None
Cathodic protection	Distributed rectifiers	Remote rectifiers	Magnesium anodes
Applied	1955	1946	1949
Current per mile	36 amperes	0.0005 amperes	0.198 amperes
Average soil-pipe potential	1.0	1.035	1.055

FIG. 2. Example of cathodic protection congestion in a common right-of-way.

tive, would require maximum cooperation between owners to eliminate wasted opposing cathodic protection currents by using jointly-owned cathodic protection systems when possible.

In design all buried pipe lines can be considered coated, even though the coating was supplied by nature in the form of oxides or soil deposits. Such coatings as these are usually considered active rather than inert; however, it might be well to consider also that present day coatings are of such a nature that they too will fail in time.

Bonding Problems

Improper bonding may be the cause of additional interference problems. Fig. 3 is presented to show the type bonds most frequently used in present cathodic protection systems. The solid copper wire bond is controlled only by the resistance of the wire, therefore it is usually supplemented by the use of a section of resistance wire to restrict operating bond current.

Rectifier-type bonding is used to prevent "circulating" currents from occurring when adjacent cathodes (pipe lines) with large differences in coating (and thus current demand) are receiving current from a common ground source.

Unidirectional bonding is used to allow current to flow from a buried structure through a metallic conductor to the offending structure, but to act as a block for current that would flow from the offending structure through the metallic conductor when the offending cathodic protection unit ceases to operate.

Recently developed germanium rectifiers are allowing increased use of this type of bond because they will allow current to flow at very low circuit voltages.

Electrolytic bonds are usually installed to provide a low resistance alternating current ground circuit between buried structures while maintaining a high resistance direct current ground circuit.

Four conclusions can be drawn from the foregoing:

1. Cost of electrical energy for protection in corrosive soils, combined with costs of inspection, operation, and maintenance of bonds, will generally justify installation of good coatings at line crossings.
2. Distributed cathodic protection units must be used on poorly coated lines in congested areas to maintain lower soil potentials and low current densities that will cause minimum interference.
3. Completely effective present day coatings will allow protection with currents small enough to prevent stray current damage to foreign structures. Thus, coating and reconditioning congested line sections will allow complete protection with reduced outputs from existing rectifier installations. Damage to existing or future structures buried near or crossing the well-coated line will also be eliminated.
4. Close cooperation and correlation of design by all companies concerned in a common right-of-way or area, will result in joint cathodic protection systems where possible, and will provide the most economical interference-free system.

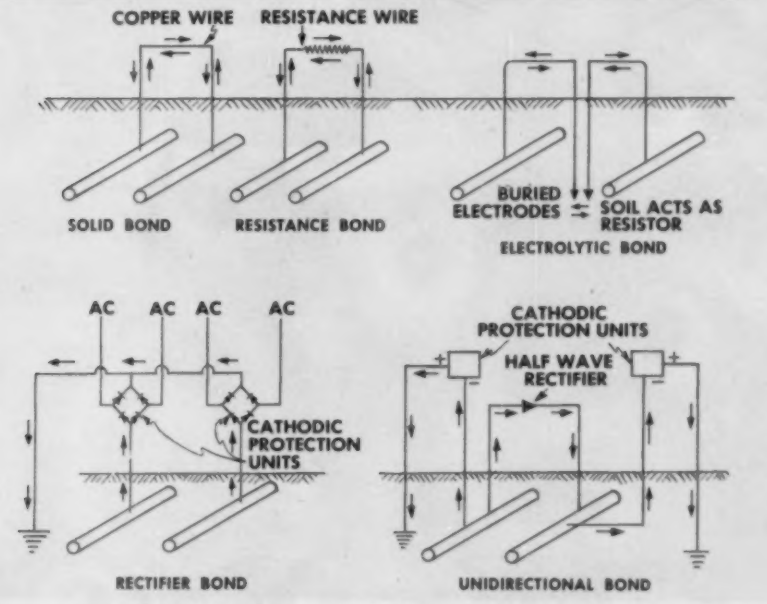


FIG. 3. Basic type of cathodic protection bonds.

Acknowledgment

The writer wishes to extend thanks to the management of Shell Pipe Line Corporation for granting permission to print this article, and to gratefully acknowledge the assistance given in its preparation by L. B. Nelson and Lyle R. Sheppard. ★ ★ ★

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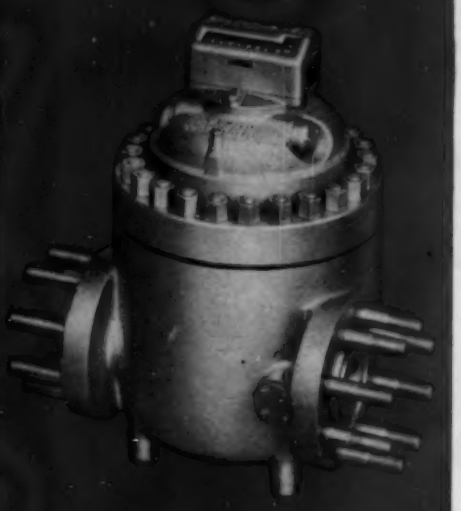


MODEL K-12 two-inch meter with horizontal counter. Double-case construction with cast steel outer housing. Rated at 3000 psi. working pressure. Capacity 171 B.P.D. 1500 psi. R.T.J. flanges.

34 MILES OUT in the Gulf of Mexico, four K-12 Meters are recording condensate production for royalty purposes. Three W-75 Meters on the pipe line measure total production. Constant accuracy is assured and tankage is eliminated.

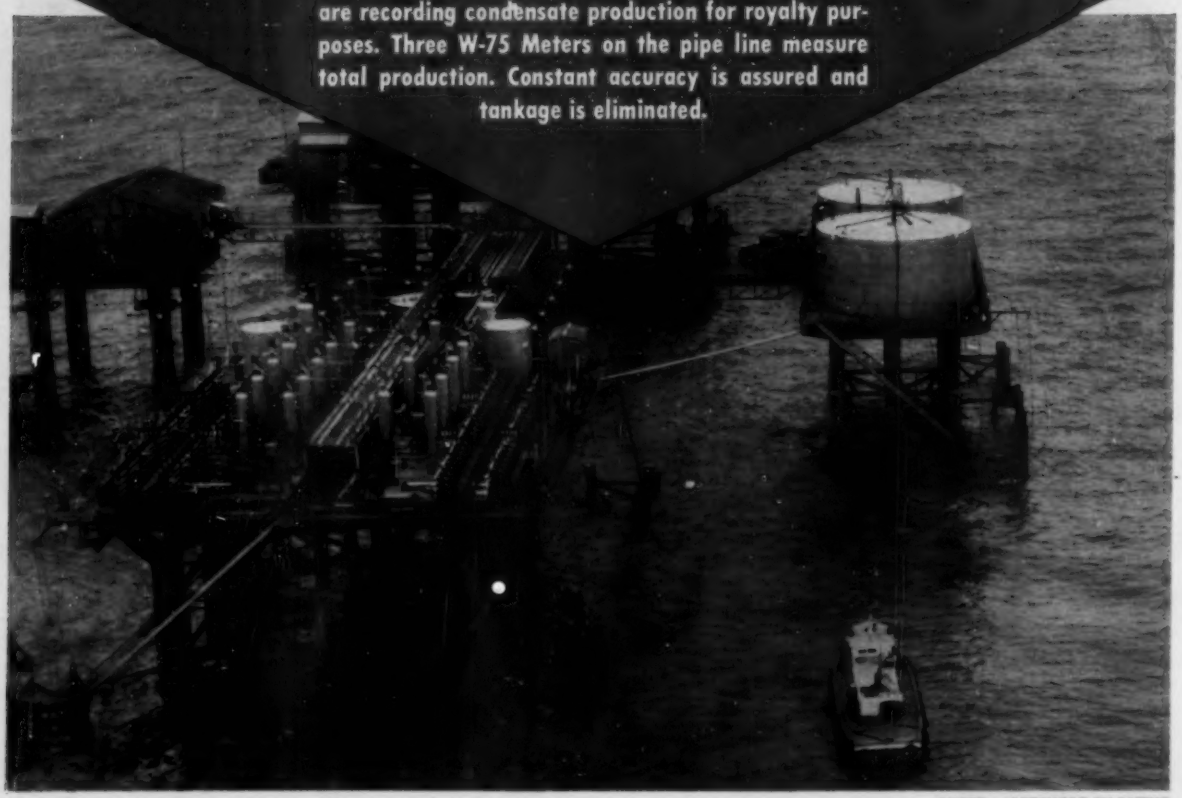


PHOTO — OFFSHORE MAGAZINE

Compressor building control panel. Suction and discharge pressures are telemetered to Houston dispatcher's office.

"In-Between" station is attractive and silent. Big exhaust silencer is hospital type, makes station noise inaudible outside station fence.

P 620.

Transco's Amazing Station 23 Designed For "In-Between" Service

Many new "wrinkles" incorporated into this compact station that features a high efficiency 3000-hp gas engine driven centrifugal compressor with great flexibility for boosting mainline thruput

Donald M. Taylor
Gulf Coast Editor

FROM top to bottom, Transcontinental Gas Pipe Line Corporation's new Station 23 is designed for "in between" service. Located almost at mid-point between the company's main line Stations 3 and 4, it takes the full stream volume of the pipe line and gives it a sizable push. Despite the fact that the station has only a single 3000-hp engine, it materially increases the throughput over this part of Transco's system where there is but a single 30-in. line.

The most important feature of any "in between" station is its flexibility. And this is what Transco engineers had in mind when they coupled a 16-cylinder, V-type 4-cycle engine to a low-head, high-volume centrifugal compressor. The engine has excellent fuel economy over a wide range of power. It has an exhaust-driven supercharger and a variable intake valve control that is actuated by the exhaust temperature. The latter enables the engine to suck a limited amount of fuel-air mix into the long power cylinders and burn it over a long power stroke. Engine speed varies from 450 to 500 rpm.

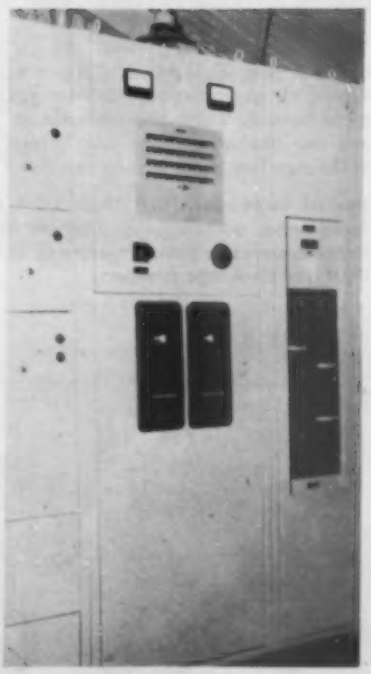
The centrifugal compressor is designed to handle almost any volume of gas ranging up to 550,000,000 cu ft per day. The differential across the station should range from about 60 psig up to 100 psig, depending on the volume of gas.

Although not automatic, the station is designed for partial unattended operation. Pressures are telemetered into the company headquarters building some 25 miles away, and the dispatcher can remotely shut the station down. Of course, the station can also be shut down by push-button, locally. But in all cases, it must be started manually.

Station Layout. Because the station is so close to the outskirts of Houston, an increase in nearby population is almost a certainty. For this reason, Transco made every effort to make the station attractive and noiseless as possible. The engine has a hospital type silencer and all exhaust piping is jacketed. The usual compressor station noises are hardly audible outside the fence.

There are four buildings at the site: The compressor building, a small meter building, and office building, which also houses much of the switchgear and control equipment, and a large warehouse. The latter is shared with the pipe line, communications, and measurement departments.

One of the unusual features of the compressor building is its two-step operating floor and truck-loading well. Because of the height of the drive end



Annunciator end of control panel in station office. Nearly all switchgear is located on panels to left of this one.

EXCLUSIVE

Looking down across engine toward compressor. Engine is 16-cylinder, V-type, 4-cycle, 3000-hp and operates in 450-500 rpm range. At left is compressor console, which contains seal oil equipment and gages.

View of compressor from above. Low-head, high-volume centrifugal type handles 300 to 500 MMCFD. Valves on either side are 24-in. full opening and are gas motor operated.

of the 10:1 spread increaser, the 24 by 24 centrifugal compressor had to be mounted at considerable distance above the normal operating floor. To solve the problem, designers raised the floor at the compressor end of the building. The truck-loading well is opposite double doors, and it permits the overhead crane to unload heavy equipment directly from truck or flat bed.

A visitor to the station is immediately impressed by the high quality construction and finish of the station. All pipe is color coded in accordance with AGA standards.

The compressor building basement, probably the industry's most attractive, houses most auxiliaries.

High Pressure Gas System. The station has five, high-pressure, big-inch valves, all gas-motor-operated for remote control. There are two suction and two discharge valves with a pair at the pipe line and a pair mounted directly on the compressor. The three valves at the pipe line — main line suction, and discharge — are 24 by 30-in. plugs with recovery tubes. The other two are full opening 24-in. and are solenoid actuated.

Gas piping inside the compressor building is 24-in. and outside 30-in. There is a 30-in. check valve on the discharge side of the station to prevent back flow through the compressor in event of engine failure.

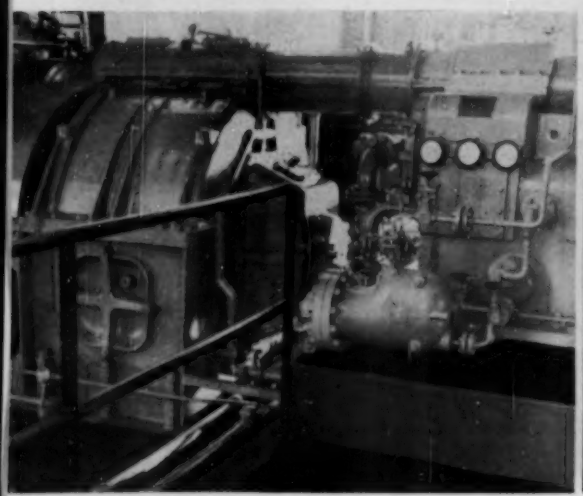
Scrubber. Incoming gas is scrubbed by a 30-in. horizontal, dry-type scrubber. It works on velocity and change of direction principles. Gas entering the scrubber flows against a striking plate and moisture and dust are impinged upon it. Next, a twir creates a vortex that slings out most of the remaining impurities. Water, condensate, and dirt are collected in a reservoir beneath the scrubber.

Compressor. The compressor is a single stage with a 30-in. wheel. It has a carbon and steel mechanical seal that allows a minute flow of seal oil into the case. Slingers direct this oil into a reservoir and a trap blows it down as needed.

Seal Oil System. A 20-psi differential is maintained across the mechanical seal by a high pressure seal oil pump. In case of an emergency, a reservoir tank mounted in the overhead and top connected to discharge gas provides a positive gravity differential. This tank contains sufficient oil supply for 30 minutes operation in case the seal oil pumps fail.

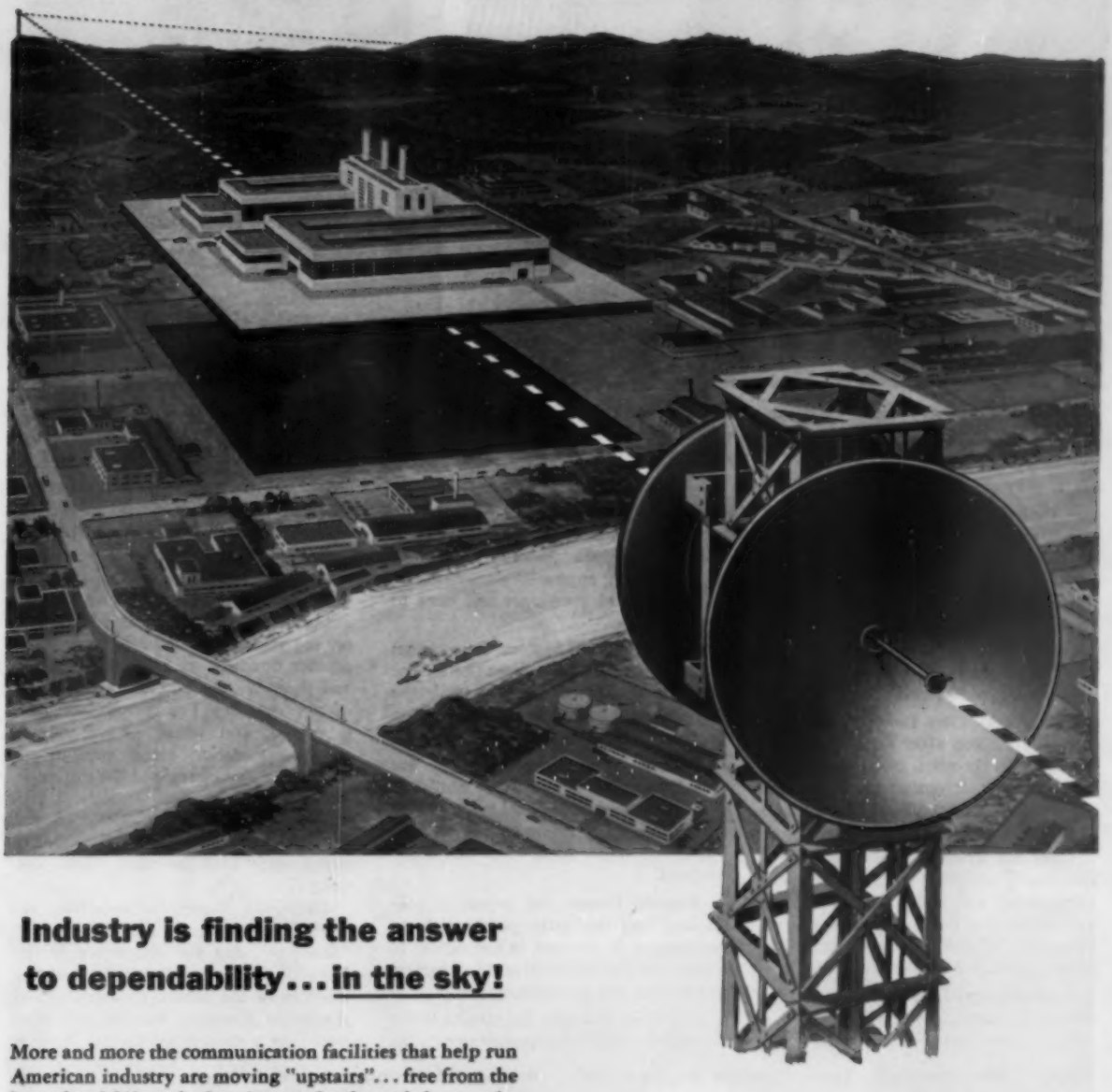
One of the safety features of the oil system is the interconnected auxiliary lube oil pump. Prior to start-up, this pump brings both compressor lube oil and seal oil up to a predetermined pressure before the high pressure seal oil pump automatically starts. Controls on the seal oil tank automatically re-start

Speed increaser (left) has 10:1 ratio. Seal oil trap, foreground, automatically disposes of seal oil that penetrates compressor seals. Pressure of seal oil is 20 psi higher than gas discharge pressure.



Atmospheric type cooler handles two water systems. "Hot" system is for jacket water and engine oil cooling. "Cool" system water cools compressor, gear, seal, and turbocharger oil.

FEDERAL MICROWAVE—"CERTIFIED BY A WORLD OF RESEARCH"



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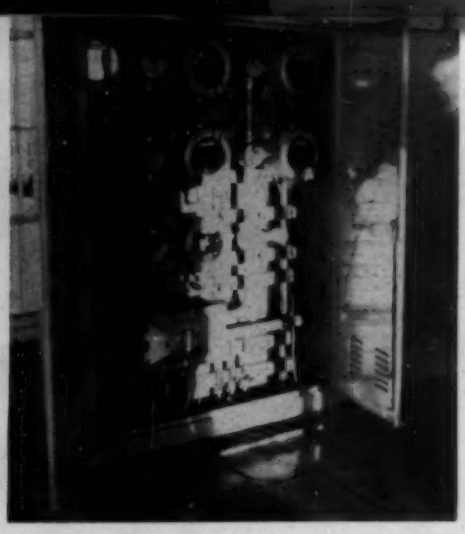
Intake air silencer and cleaner was designed for horizontal installation. Air is supercharged to about 10 psi before it enters the 4-cycle engine.



Mercury switches, shown in cabinet, perform functions designed for station shutdown. Station is started manually.

this auxiliary pump when oil reaches a low level. If the oil level continues to fall, controls will shut down the station.

Engine Lube Oil System. An engine driven pump circulates lubricating oil through a cooler and twin strainers. A side stream of 12 to 15 gal per min is diverted through an additional filter and the station is equipped with a centrifuge and oil purifier.

Before and After Lube Oil Circulation. Before and after start up, about one-third of the oil is circulated by an electric motor-driven pump. The pump automatically shuts off when the main lube oil pump overrides it.

Gear Oil System. The gear oil system also is equipped with a before and after pump; and it also has a shaft-driven pump that has overriding control. Gear oil is filtered through a magnetic filter as well as a conventional one.

Turbocharger Lube Oil System. This system is complete within itself with a 10-gal sump and pump in the basement. The oil is pumped through a small cooler and filter, then to the turbocharger. It drains by gravity back to the sump tank. In event of failure of this system, engine oil automatically flows to the turbocharger and back to the crankcase.

Compressor Oil System. This system is completely separate from the others. The main lube oil pump is shaft driven and the auxiliary oil pump and seal oil pumps are electric-motor driven.

Cooling Water System. There are two separate systems. The "hot" system cools the engine jackets and lube oil in the conventional manner. The "cold" system cools the other oil systems.

Electric Power. All power is purchased and the main portion of the switchgear is situated in the office. In event the power fails, a 48-v battery takes over the instrumentation.

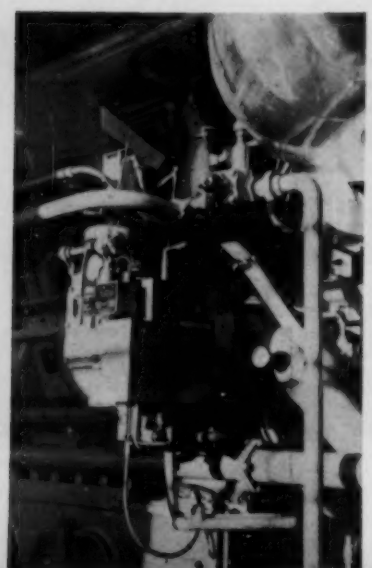
Controls. Because the station is not intended for fully automatic operation, most control functions are aimed at shutdown, because in all cases the station must be started manually.

In case of power failure, the station shuts down with the fuel valve closing and venting the engine fuel headers to atmosphere. The gas motor operators on the two 24-in. valves in the compressor building are solenoid atcuated and these valves can close in a matter of two minutes. The compressor case is vented, and when the differential across the station block valve nears zero, the valve opens and the station is bypassed.

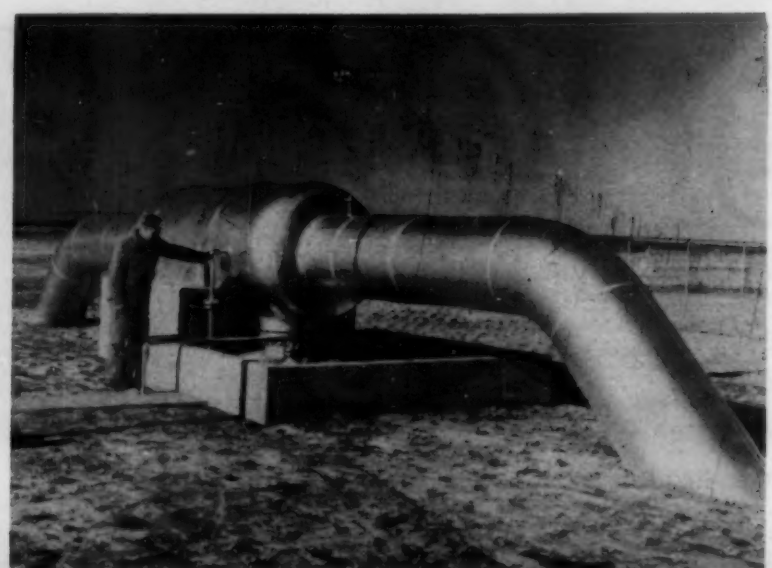
When the station is shutdown for reasons other than power failure the compressor case normally does not vent.

Once the station is manually restarted, the controls are switched to "*Dispatch*" and the dispatcher in the Houston office can not only read the position of the valves, the suction and discharge pressure, but he can shut down the station if he desires. ★ ★ ★

Intake valve controls. System enables engine to take limited fuel-air mixture, burn it over long power stroke.



Horizontal scrubber uses centrifugal motion and change of direction to remove solids and moisture from incoming gas stream.



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A comprehensive microwave survey is the basis for selecting paths, tower heights and radio equipment. Such a survey is a sound investment in firm planning, bidding and guaranteeing performance of a microwave system.

This article covers the technique of surveying in mapped and unmapped areas. The author makes some pointed suggestions concerning survey responsibility for the sake of most effective and economical overall usage of available engineering talent.

The end product of a microwave survey is a profile for each path, supplemented by data on sites and propagation factors. A profile chart is presented on page D-46 for use as shown in the sample Fresnel clearance problem in Part 1. Standards for survey reports are suggested in line with the requirements for planning and guaranteeing microwave systems.

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PLANNING A MICROWAVE COMMUNICATION system requires the same type of engineering approach and evaluation techniques as are employed in planning a pipe line construction project. In both cases, preliminary surveys are required to study the requirements, routing and probable cost. If this analysis indicates that the project is economically justified, then construction is authorized and the detailed survey and engineering commence.

Communication Economics

The major differences in planning a microwave system and a pipe line project are in the dollar magnitudes involved and in the future demand factor. Installation of a microwave system involves approximately 1 per cent of the total cost of constructing a major pipe line, although the later addition of related pipe line control and communication facilities may ultimately amount to 5 per cent of the pipe line investment.

The ever-increasing demands of communication traffic and the growing trend toward remote control and automation necessitate careful planning of communication facilities for future expansion. Fortunately, microwave systems are more amenable to expansion in step with future demand than are pipe lines, which have their capacity fixed by initial diameter. A well planned microwave system may have additional channels, spur links or major extensions added as required by future operations. For full use of this growth potential, a microwave system must be planned for the ultimate required channel capacity and should be routed for proximity to future service points.

This growth aspect of microwave traffic should be considered in the preliminary survey, since the economic justification and pay-out rate are both increased by the later addition of channels.

Communication economics will be treated later in this series by a group of graphs depicting the various cost elements. The number of stations and tower heights can be determined by survey techniques such as outlined below. The selection of antennas, radio system, channeling equipment, and related apparatus for specific operational requirements will be covered in subsequent articles. With the system elements and parameters selected to satisfy the requirements, the cost graphs can then be employed to approximate the total cost for various combinations and to gage pay-out rate as a function of channel usage.

Topo Map Survey

Planning a multi-hop microwave system requires the accumulation and analysis of a number of maps. **Topographic** maps which show terrain features, contour data, man-made structures and transportation routes are extremely useful in selecting tentative propagation path routes and station sites. The elevation data from topographic maps can be plotted on profile charts to ascertain tower heights re-

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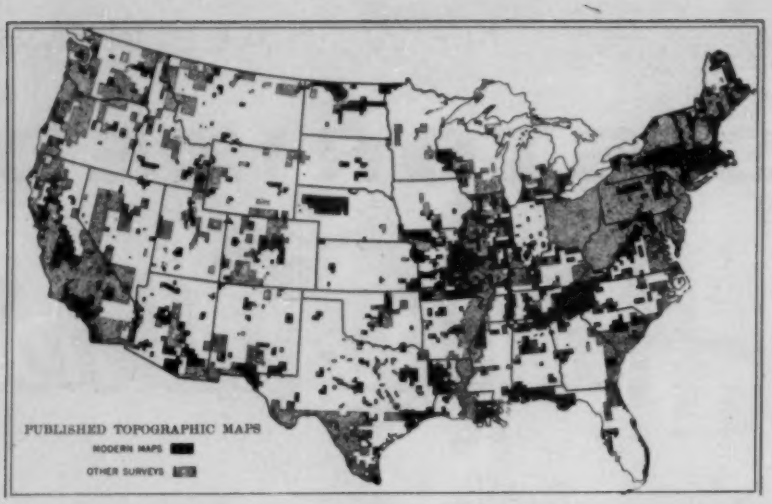

FIG. 1. Areas covered by 10,000 published topographic maps available from U. S. Geological Survey. Microwave paths through mapped areas can be planned by paper survey and field checks. White areas require field surveying by altimetry radar profiling, aerial photogrammetry or propagation tests.

quired for proper path clearance over the intervening terrain between station sites.

Microwave routes in areas covered by recently published topographic maps can be quickly and accurately surveyed on paper, with a minimum of field survey cost.

The most useful and accurate maps available generally are U. S. Geological Survey quadrangle maps and similar topographic maps surveyed by other government agencies.

Nearly 50 per cent of the United States is covered by published topographic maps as shown in Fig. 1. Many of the maps in the gray areas are antiques, but the contour data are valuable even when the cultural data are completely out-dated. Recently mapped areas denoted by black are covered by modern maps of high accuracy and detail.

The importance of accurate contours or elevation data is obvious in microwave profiling. Standards for vertical accuracy of topographic maps require that 90 per cent of the elevations interpolated from the contours shall be correct within a tolerance of one-half contour interval. Maps which meet this 1942 standard are so noted.

The accuracy of microwave elevations is a compromise between survey cost and the cost of safety factor in tower height. A practical approach is to obtain elevation data at sites and critical obstructions accurate to within ± 5 ft average and ± 10 ft maximum, then add a margin of 10 to 20 ft over all obstructions in plotting Fresnel zone clearance. Occasionally, however, a problem path may require accuracies of ±2 ft for precise analysis.

Maps with contour intervals of 5, 10, or 20 ft are ideal for microwave path planning. Maps with contour intervals of 100 ft or more are useful only for approximating path clearances and tower heights.

Most existing USGS quadrangle maps covers 15 min of latitude and longitude and are published at a scale of 1:62,500 (1 in. = nearly 1 mile). The contour interval varies from 5 to 100 ft, depending upon steepness of terrain.

Areas of high industrialization or public development are usually mapped in 7½ min quadrangles for greater accuracy. Map scales are 1:24,000 (1 in. =2,000 ft), or 1:31,680 in older maps. Contour intervals range from 1 to 50 ft.

The more remote and undeveloped areas, if covered by topographic maps, are scaled at 1:125,000 (1 in.=nearly 2 miles) or 1:250,000 with contour intervals of 20 to 250 ft.

All present large-area topographic mapping operations by government agencies employ aerial photogrammetry and precise stereo plotting instruments supplemented by ground surveying. The relative speed and accuracy of this technique makes it economically practical to survey the entire country within a decade or two.

Within several years the entire country will be covered by a series of topographic maps being prepared by Army Map Service and published for civilian usage by U.S. Geological Survey. The series will cover the U.S. in quadrangle units of one degree latitude by 2 degrees longitude on a scale of 1:250,000 (1 in.= approximately 4 miles).

Contour intervals vary from 25 ft in flat terrain to 500 ft in mountainous regions. This AMS series is useful in preliminary planning but must be supplemented by detailed USGS quadrangle maps and/or field surveying.

Recent maps indicate wooded areas by a green overprint. The height, density and margin for future growth of such vegetation can be gaged only in the field.

The 10,000 topographic maps prepared by USGS, TVA, Army Map Service, Forestry Service, and Coast Geodetic Survey are now distributed by USGS. Full information concerning the availability of topographic maps, state index circulars, aerial photographs and bench mark locations for vertical and horizontal control can be obtained from the Map Information Office of the USGS in Washington.

Other Maps

Plastic relief maps covering mountainous areas in California, Pennsylvania, New Jersey and elsewhere have recently become available from AMS and several commercial services. The AMS maps are scaled 1:250,000 with contours and cultural data printed on the plastic surface in exact accordance with the regular paper series published at the same scale and planned to cover the country.

These "3-D" relief maps are quite useful in microwave path planning over rugged terrain. A straight edge may be used to roughly check paths for line-of-sight transmission. Detailed maps must then be employed to obtain more exact elevations at the sites, obvious critical points and midpath. Profile charts for a number of alternate paths and sites can thus be plotted in a few hours.

Fig. 2 illustrates the use of a plastic relief map of the Los Angeles area to simulate a line-of-sight path up Violin Canyon toward Bakersfield. The 2:1 vertical exaggeration of relief facilitates rough gaging for clear paths. This 37-mile path between Los Pinetos Peak and Tejon Lookout is now in use for a 2000 mc system, and a second microwave system is planned over this route by Richfield Oil Company.

Aeronautical Charts provide complete coverage of the U.S. in 2° by 6° sections on a 1:1,000,000 scale with 1000-ft contours and up-to-date cultural topographic data. U.S. sectional charts and similar world aeronautical charts covering the rest of the globe are published by U.S. Coast and Geodetic Survey and available at all principal airports. These charts are useful in approximating microwave routes and relay intervals for budgetary cost estimates.

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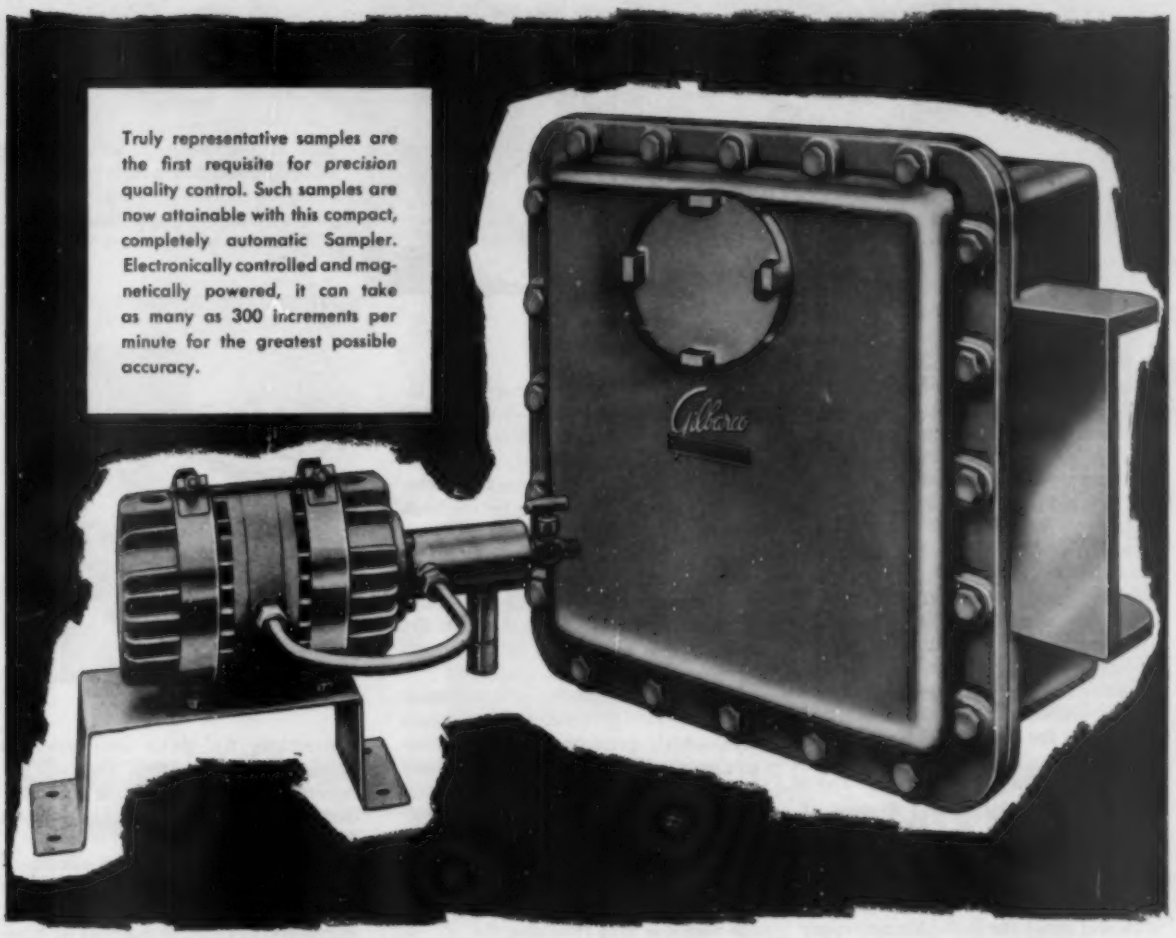
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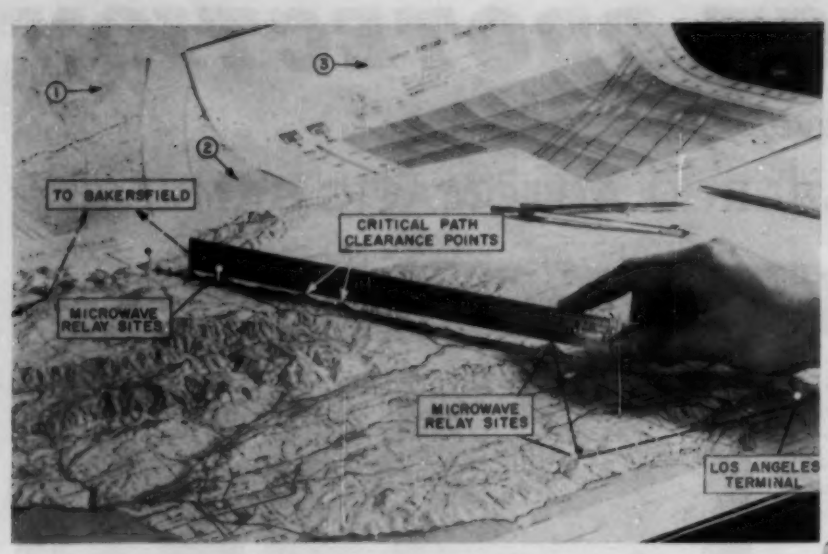

FIG. 2. Plastic relief map and straight-edge simulate line-of-sight path in planning microwave route over rugged terrain. Clearance at obvious critical points must be checked by plotting accurate elevations from topo map (1) on profile chart (2). Required clearance is read from Fresnel zone chart (3).

FIG. 3. Stereo viewer being used to obtain topographic data from overlapping aerial photogrammetric prints. Optical gage reads height differential with respect to known elevations.

eration in site selection. The magnetic declinations shown on these charts are useful in field surveying. In filing for construction permits, station sites may be shown on aeronautical chart strips that accompany the license application and serve as system route maps for FCC and CAA information as to tower lighting requirements.

State and county road maps, railroad maps, and other maps prepared by state or local governments or public utilities are often useful in locating sites with respect to access roads or primary power. AAA road maps provide up-to-date and detailed information on road conditions for year-around access.

Field Checking

After accumulation and analysis of topographic maps, tentative sites are selected, and the alternate routes are plotted on profile charts. A field survey crew is then sent to investigate the sites and check the path. Altimeters are used for accurate measurements of elevations at sites and critical points. The path is visually checked for possible obstructions, atmospheric problems and terrain reflections.

Unmapped Areas

For microwave path profiling, any area not covered by topographic maps is considered unmapped. The white areas in Fig. 1 require more extensive field surveying to obtain the necessary elevation data. The survey technique employed may be altimetry, radar profiling, photogrammetry or combinations of these. The choice of method depends upon the available data, field conditions and resultant cost as summarized below. All three methods provide elevation data within the accuracy required for microwave path planning.

1. ALTIMETRY

Field surveying with a sensitive altimeter is generally the most practical method for short microwave systems in areas with ready access, good planimetric maps, and bench marks for elevation references. Altimetry methods are also employed in field checking sites and critical elevations over topomapped areas. Consequently this method is economical for filling in the unmapped areas in long microwave systems that have most of the routes covered by topographic maps.

A surveying altimeter is a null-reading aneroid barometer that reads atmospheric pressure and has a sensitive gage calibrated in feet above mean sea level rather than inches of mercury column. The instrument is calibrated in the field by adjusting the reading to agree with the elevation at a bench mark or known reference. When the altimeter is moved to a new location, the height is then read directly.

Since the altimeter is actually gaging air pressure which constantly changes, it is necessary to correct for this variation. This is accomplished by using two or more altimeters for simultaneous readings at the reference and check points. The heights read on the roving altimeter are later corrected by the amount of height differential indicated on the base altimeter at the same time. The base altimeter and roving altimeter are compared before and after a series of readings to assure instrument equalization, within $\pm$ 5 ft.

Accuracy of measurements is affected by changes in air density caused by variation of temperature, relative humidity and gravity. Temperature has the greatest effect. Relative humidity necessitates correction only when high humidity occurs at high temperatures. Corrections for these environmental conditions are obtained from calibration charts supplied with the altimeter. The gravity correction is insignificant for microwave purposes.

Altimetry should not be attempted during unstable atmospheric conditions such as occurs with high wind gusts or inclement weather. A number of readings, spaced in time to allow for movement of air columns, are taken and averaged for accuracy. Readings are limited within an area of constant weather conditions and should not be made in early morning, late afternoon, or other period of changing temperature.

For elevation control, bench mark data may be obtained from USGS, USCGS, River Commissions, and other federal or state agencies.

During good visibility, sighting between obstruction points may be used to reduce intermediate readings. The speed and accuracy of surveying with altimeters varies somewhat with the method employed as noted below:

The single-base method outlined above employs one fixed altimeter at a bench mark reference, and one or

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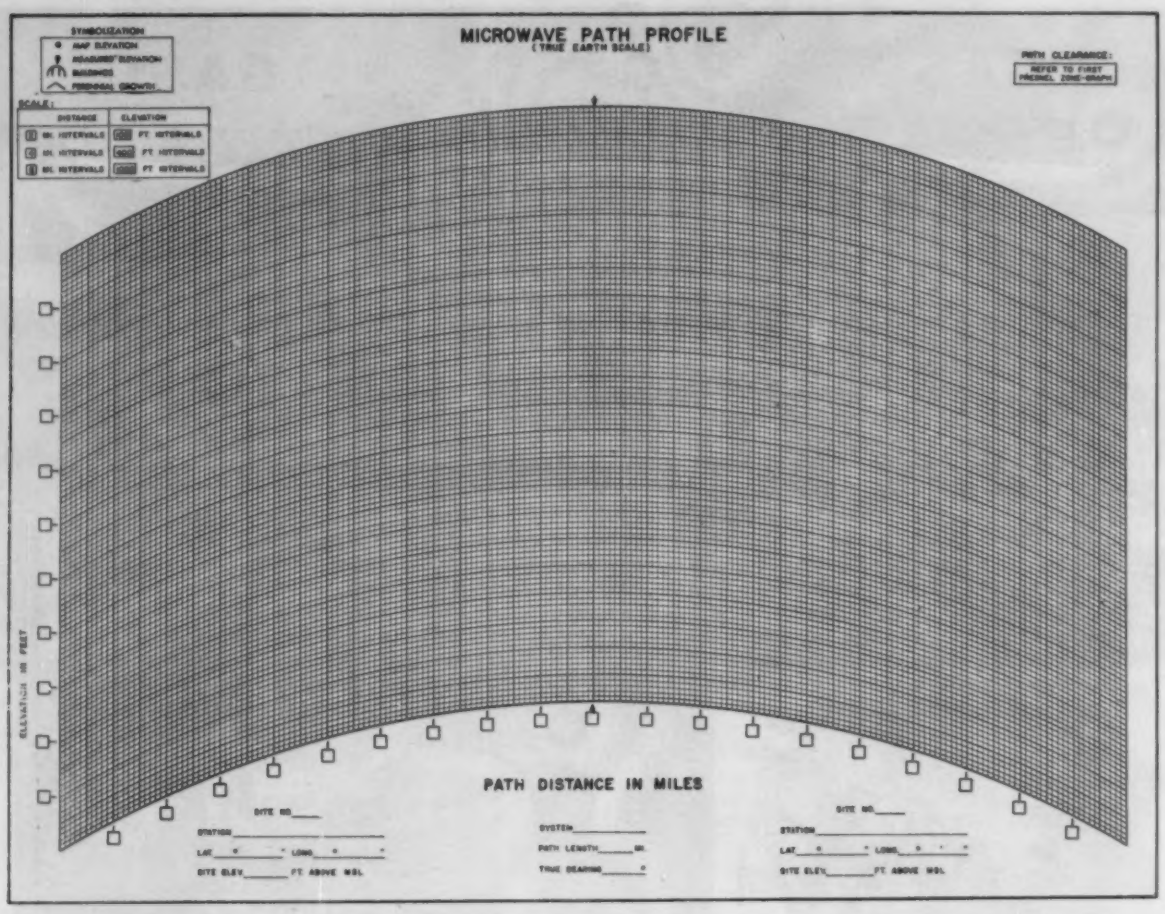

more roving altimeters which return to the fixed base after a series of readings. Accuracy is ± 5 ft average and ±18 ft maximum as long as the roving altimeter stays within a 15 mile radius and within 1000 ft of the base elevation. Within 300 ft elevation, the average error is 3 ft and maximum 12 ft.

The two-base method employs a high and low base site and several roving altimeters. A simple proportion provides the correction for actual height of the intermediate check points, without temperature and humidity corrections. The method is more accurate and more expensive than single-base operations and is more suited for photogrammatic contour checks than microwave profiling.

The leap-frog method effectively carries the base altimeter along with the roving altimeter by "leap-frogging" the two altimeters and comparing them at alternate stations. The method is very accurate and relatively fast when coordinated by mobile radio on each vehicle. Since the two altimeters are always close, they operate under the same atmospheric conditions. Accuracy is ± 1 ft average and ± 4 ft maximum.

The cost of microwave profiling by altimetry varies from $15 to $35 per mile, depending upon the availability of topo and planimetric maps, location and length of the system, weather, and access to bench marks and check points. Full information on sites and paths is readily noted for inclusion in a complete survey report. A surveying altimeter crew will cover an average of 20 to 40 miles per day, depending largely upon access and weather.

2. RADAR PROFILING

Airborne radar profiling of microwave paths is a rapid and economical means of surveying over routes where good topographic maps are lacking, planimetric maps are sketchy, access is difficult, or bench marks are scarce. In a long survey in which time is of the essence, this method is unequaled.

The technique of radar profiling as developed by Captain W. C. Eddy was described in the *May, 1955,* issue of *The Petroleum Engineer*. The resulting path profiles are referenced to ground elevation checks and supplemented by terrain and atmospheric data, site information, and aerial photographs. Such survey reports provide a sound basis for system planning. This radar profiling service is now being employed by a number of microwave users and suppliers for surveying paths in the U.S. and abroad.

The microwave planner should furnish a representative to inspect tentative sites with the aerial survey crew and to locate these sites in high-level air reconnaissance. The low-level path profiling run is flown only by the aerial crew.

The cost of a complete aerial survey and report can be contracted for approximately $20 per route mile plus a travel cost of $1 per mile to transport the aircraft and crew to the job site. Survey costs outside the U.S. average 50 per cent higher per route mile plus double travel rates. Expenses should be allowed for a representative to accompany the survey crew in locating sites.

A radar survey crew can produce path profiles at an average rate of 100 route miles, or up to 150 miles per day under ideal flying conditions.

3. PHOTOGRAMMETRY

Aerial photogrammetry is useful in

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developing skeleton topographic maps for locating sites and plotting path elevations over areas for which essentially no information is available. This method is most economical only when a relatively large number of alternate routes are being investigated over uncharted terrain. Photogrammetric techniques are sometimes feasible for filling in gaps between topo-mapped areas.

This technique is based on 3-dimensional aerial photography. Successive photographs are taken at high altitudes at displaced positions along the flight route so that the photographed areas overlap. When the overlapping photographs are viewed through a stereooptical system, as in Fig. 3, the right and left eyes see the same area as viewed from the two displaced aerial positions.

The 3-D "depth" can be gaged by focusing the optical system on a reference point at which the scale is zeroed. As the stereo viewer is refocused on check points along a path the height differential is read directly off the scale in feet. In contour plotting, the desired interval is set on the scale, and the viewer is made to trace the in-focus elevation level.

Matched aerial photographs of areas that have been photo-reconnoitered can be purchased at low cost, but the stereo analysis and plotting of skeleton topo maps is a lengthy process. Photogrammetry service organizations with stereo plotting instruments will produce topo maps from such available photos to any desired detail.

Aerial photo reconnaissance can be contracted for path areas not covered by existing photographs. Preparation of 25-ft contoured maps with ± 10 ft accuracy may cost $12 to $18 per square mile, or approximately $150 per system mile, for a strip 8 miles wide through remote mountainous country.

A more practical and economical approach is to prepare rough "skeleton" topo maps for preliminary path planning, then have accurate elevations filled in along the path routes selected. The cost of such service is $30 to $60 per microwave system mile, depending upon the availability of negatives, location and extent of the paths and the amount of contour information desired.

Other Microwave Survey Methods

Propagation tests to ascertain transmission over radio routes are not economically feasible for general usage. Portable towers, radio equipment, generators and crews for two ends of a test path are costly to set up and operate. Evaluation of the path under various propagation conditions requires the use of strip recorders to analyze received signal over a period of time to determine "normal" operation and the extent of fades.

A practical variation of the propagation test method may be employed for problem paths such as off-shore microwave links. The RF system can be designed for ready incorporation of frequency diversity if required. The initial installation will then serve as the "test" to see if propagation reliability is adequate. If not, diversity RF can be added to assure reliable operation.

Optical path testing by sighting elevated signal lights at night is not adequate for microwave path planning. The location and elevation of critical obstruction points determined by these methods is not sufficiently accurate because of refraction of the light beam.

Simple daylight viewing may suffice between sites such as an office building, existing tower or hilltop locations. If there is any doubt about clearances, a rough profile should be plotted.

Helicopters offer interesting possibilities for surveying inaccessible areas by altimetry, transit and simple photography. In South Louisiana, for example, this is an excellent means of checking over-marsh paths for the extent of reflective surface and height of masking vegetation.

Survey Reports

A microwave survey report should be a comprehensive and accurate reflection of the engineering which went into the survey. The report will be the basis for confirming site and path selections, design of the RF system, firm price bidding, and guarantees of system performance.

The main products of the survey are the profile charts and accompanying description of terrain and atmosphere factors affecting propagation.

The survey procedure should be outlined, and a statement as to the degree of profile accuracy should be included for evaluation and consideration in planning tower heights.

The path description should include full information on terrain features, foliage, reflective surfaces, ground roughness, fog or smog patterns, temperature inversion levels and air turbulence. Off-path hills, saddles, valleys and ridges are noted as possible advantage points. Trees and man-made obstructions are noted as possible interference, masking, or reflecting objects.

Full site descriptions should include photographs and drawings of existing structures, plot layout drawings with rough contour data for tower guy

orienting, approximate soil bearing if below 3000 psf, classification of soil and possible subsurface rock strata. Full information should be provided on year-round condition of access roads and any required road building or improvement. The nature of available electric power or length of required power pulling should be accompanied by the name of the utility for further information.

Simplified site location maps and later site marker signs will avoid lost motion and win the good will of installation engineers, delivery truck drivers, tower erection and building construction crews — especially if the maps show the route toward the two adjacent sites and indicate nearby motels.

An overall system route map should be included, preferably on an aeronautical chart strip. Path and performance calculations are best made by the suppliers who will bid and back the operation of their equipment over the system.

Reasons for selection of recommended sites or paths should be outlined, and alternate choices should be pointed out for consideration of possible passive repeaters or similar techniques. Possible frequency interference from nearby microwave stations can be prevented if the location, frequency, path bearing and dish pattern are noted.

Survey Responsibility

The following ground rules concerning survey responsibility have been followed in several recent microwave system contracts. More widespread adoption of these procedures would result in most effective and economical overall usage of engineering talent on the part of microwave users, suppliers, and survey organizations.

If the survey responsibility is shirked, or if a survey report does not meet comprehensive engineering standards, the resulting duplication of survey effort and/or costly oversights in bidding are wasteful of limited manpower and dollars. The resulting costs are passed on to the purchaser either directly, or ultimately through higher pricing of future microwave systems.

1. WHO SHOULD SURVEY?

Microwave surveys may be conducted by the communication department of the user, by the systems engineering department of a microwave supplier, or by an independent survey organization. The choice should be based on the survey technique required, availability of experienced personnel, desired engineering results, and economy.

Survey by a competent engineer in the user's employ may be most economical, but if he is not experienced in microwave, some resurveying by the supplier will be required to check the results before accepting responsibility for performance over the surveyed route.

Survey by the systems engineering department of a supplier assures experienced personnel, guaranteed propagation over the path, full attention to all engineering factors in system design, and consideration of all innovations and new techniques which may be available at the time of equipment delivery (e.g., use of back-to-back dishes for passive relays, scatter hops, ferrite applications, etc.) A comprehensive survey and report made to professional standards by a microwave systems engineer can be used for bidding and planning by all suppliers.

Survey by an independent survey organization such as MSI, TAI, or others experienced in microwave will provide a comprehensive survey report with profile accuracy and path data fully acceptable to all suppliers.

A surveying and consulting service must of necessity be highly objective in selecting paths or making recommendations. To assure full consideration of all possible solutions to the customer's point-to-point communication problem, the survey organization should keep up with new developments in equipment and new techniques in system layout by the suppliers.

2. WHEN TO SURVEY?

Any large microwave system should be surveyed **prior to bidding,** and the survey report should accompany the specifications and bid request. Firm bids on a system must be based on a survey, and duplicate surveying by several manufacturers is a ridiculous waste of engineering manpower.

Surveying prior to bidding will result in lower bids, since full information greatly reduces the contingency money. If full survey data are not made available to bidders, each bid will naturally include the price of a field survey.

3. WHO SHOULD SPONSOR?

A survey prior to bidding should be initiated and paid for by the purchaser of the microwave system. This avoids moral obligations, assures the availability of data to all desired bidders, and provides a good basis for obtaining sound, low bids. A good survey is a low-cost, sound investment if the user is serious about microwave.

The preparation of a detailed engineering proposal and bid quotations on a custom installed microwave system involves thousands of dollars in speculation by a supplier. It is only fair that the purchaser invest in a survey to provide the information necessary in planning a turnkey solution to his communication problems.

4. WHO SHOULD GUARANTEE RESULTS?

The surveyor should guarantee the accuracy of his profiles within a specified tolerance. Based on that guarantee and full information for path evaluation, the supplier can accept responsibility for performance of the system over the specified paths.

Path Planning Factors

Practical aspects of site selection and propagation considerations in microwave path planning will be covered and graphically demonstrated in Part 3. Later articles will summarize the RF and antenna paremeters, tower considerations, and innovations in point-to-point communications techniques—all of which effect path length and site selection.

A microwave profile chart is illustrated in this article. The chart is based on true earth curvature and may be used for conservative and physically realistic path planning at all four microwave bands by following the sample procedure in Part 1 and allowing for beam bending and terrain reflections as charted in Part 3 next month. ★ ★ ★

Socony Mobil Completes Push-Button Terminal

Socony Mobil Oil Company has formally opened its new "push-button" pipe line terminal in Linden, New Jersey.

All tank truck loading of gasolines and other petroleum products is controlled from a battery of electronic devices on a long desk in the terminal office.

Safe and easy loading is also facilitated by a two-way communication system. The 64-acre terminal has seven tanks for storing six different products, and includes 22 tank truck loading points; provision for loading railroad tank cars; and a building for general offices, warehousing and garage.

The new terminal is managed by Harold W. Essig, who has managed the Socony Mobil plant at East Rutherford.

The Linden pipe line terminal is supplied directly by a 12-in. pipe line from Port Socony, Staten Island.

The five-mile pipe line supplying the terminal was one of the shortest, yet most difficult, pipe line projects ever undertaken by the company. The possibility of high tides required construction on the New Jersey side of a high roadbed of clay, sand and gravel.

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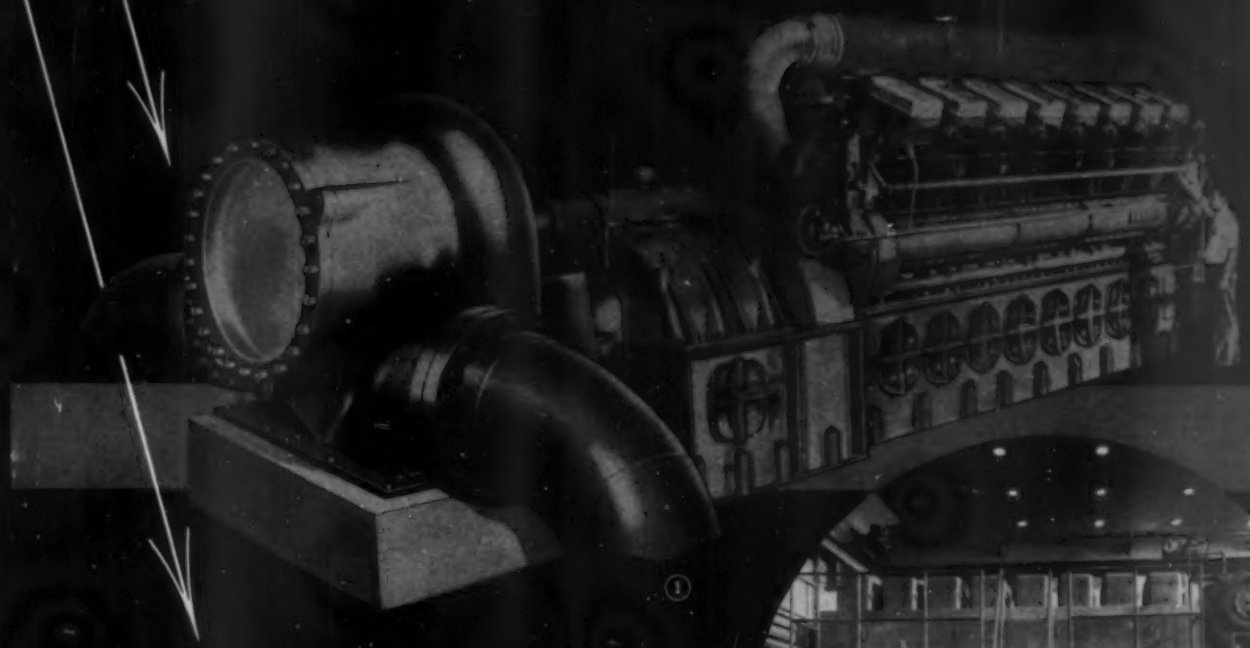

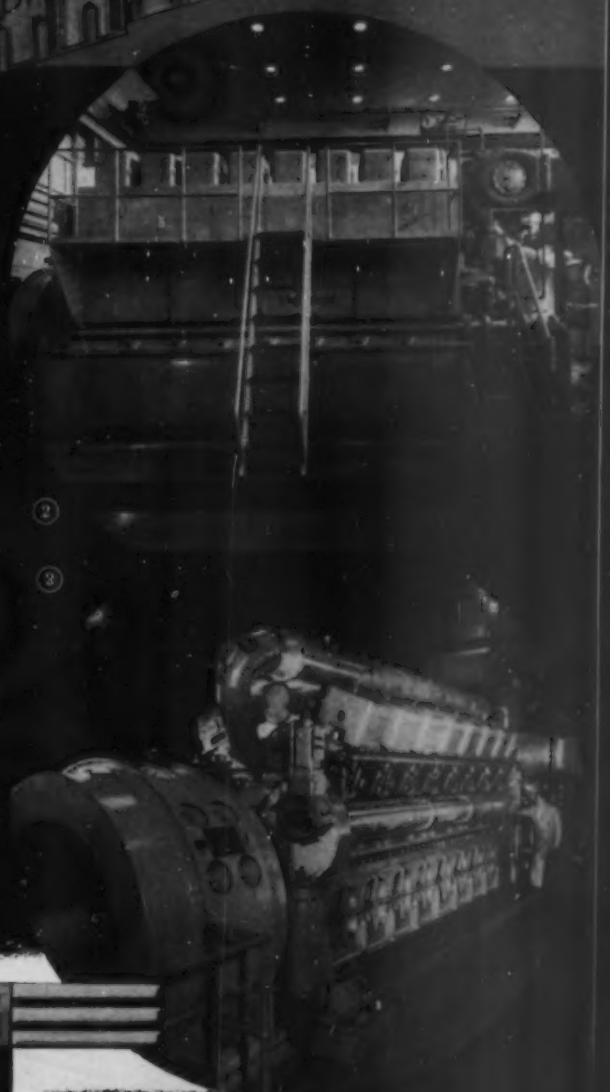

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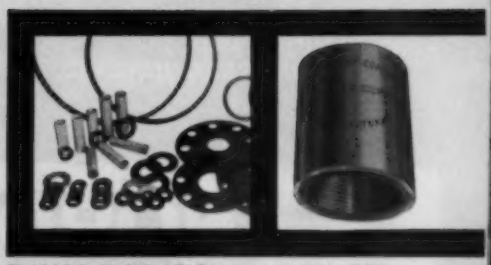

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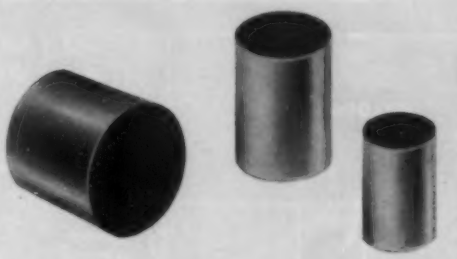

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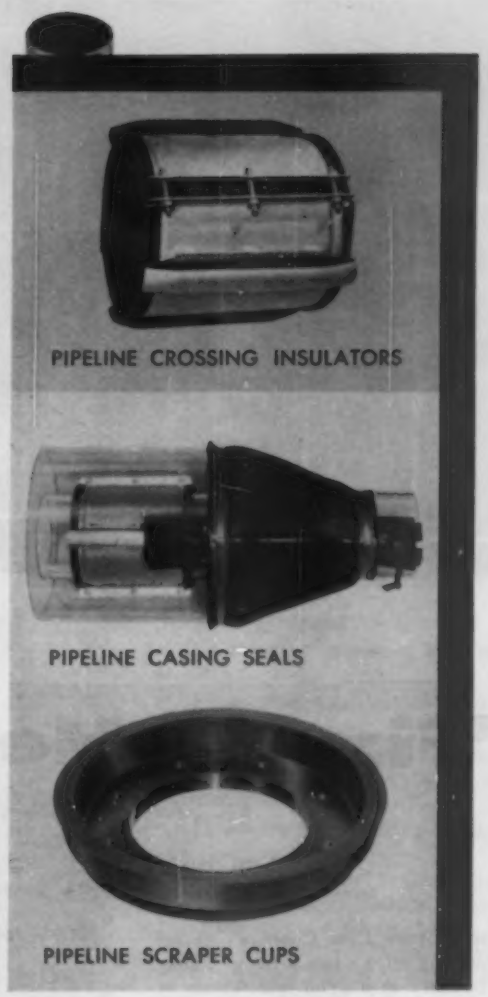

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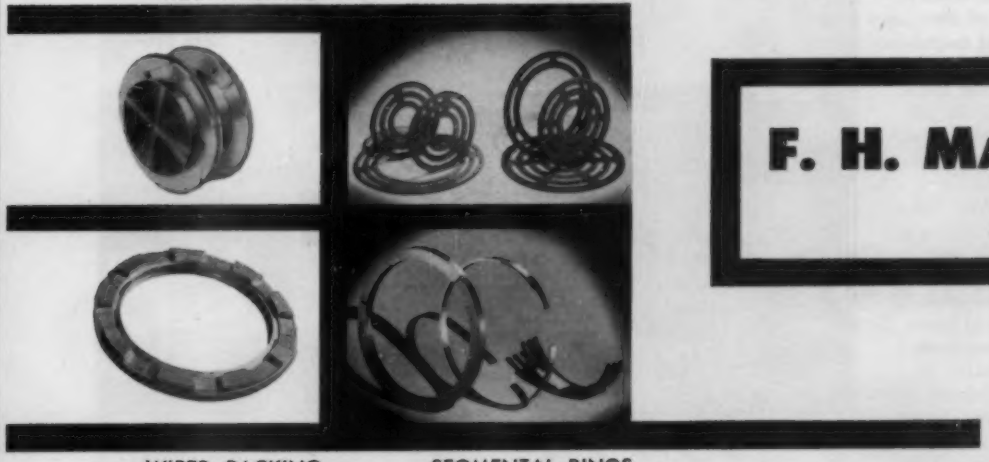

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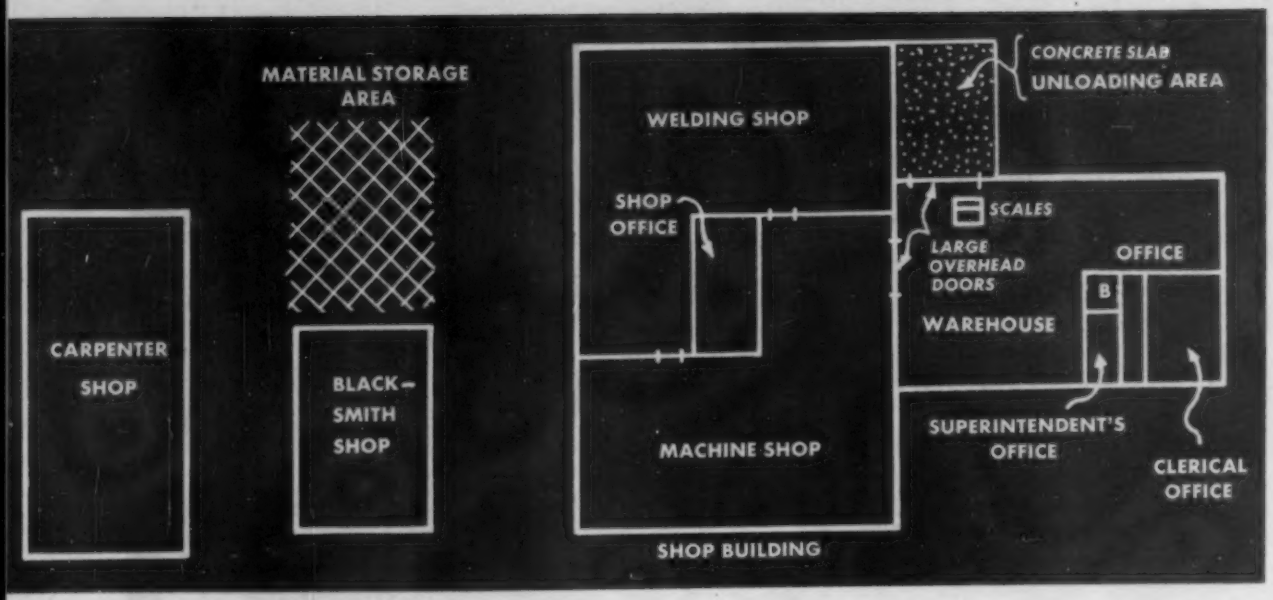


"Fix It" Headquarters

Carl Huss
Service Pipe Line Company

At Service Pipe Line Company's Tulsa Shops, they not only make repairs—and fast—but also build and test new equipment and methods

SERVICE PIPE LINE COMPANY FACED a pumping crisis when a pump crankshaft broke in a main line station in Missouri recently.

A hurried call to the factory brought the information that a new shaft couldn't be delivered for 10 weeks. Future pumping commitments demanded that the pump be back in operation in six weeks, or lose money.

Time: Five weeks instead of 10.

Such emergencies are one of the reasons that the company maintains its shops in Tulsa. And as usual, the shops came through on the crankshaft job. They received the three-ton broken crankshaft three weeks after the breakdown.

Forewarned and armed with blueprints the shops personnel already were machining a 1740-lb forging into a new section for the crankshaft.

They planed off the broken section, manufactured the necessary bolts, studs and nuts, drilled holes and bolted the new piece to the crankshaft.

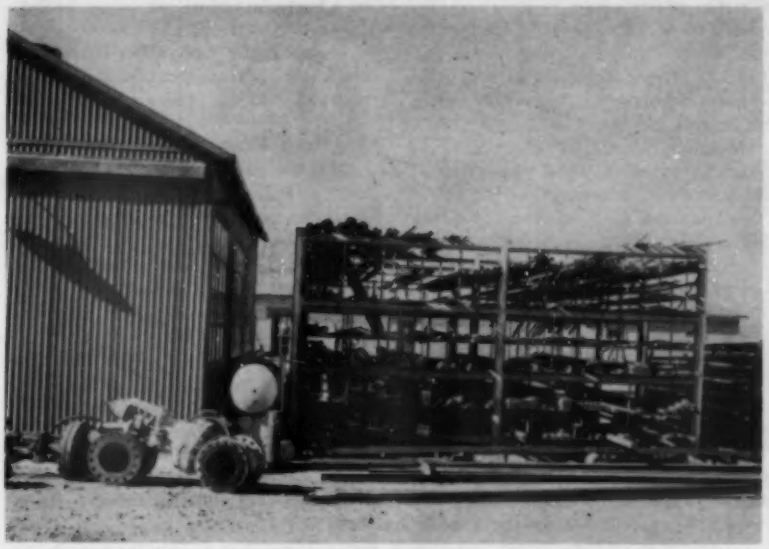
They had the repaired crankshaft on its way to the pump station just 15 days after its arrival at the shops.

By having the shops, Service Pipe Line not only met its pumping com-

Exterior view of Service Pipe Line's Tulsa shops shows the newly completed office and warehouse, right, and the old building rear that houses the machine and welding shops.

Machine shop interior. Overhead hoists carry heavy pieces to the various machines. Wide doors at rear permit trucks to back into shop for loading.

Blacksmith shop equipment includes a forge, right, and forging hammer, left rear. Not visible is automatic heat-treating furnace for small engine and pump parts.



Storage rack holds piping, angle iron, bar steel used by the shops. At left is blacksmith shop; beyond storage rack is carpenter shop.

mitments, but got the job done for one-fourth the cost of a new crankshaft.

Purpose of Shops

The company organized the shops in 1926 to

(1) do work that couldn't be done elsewhere;

(2) perform emergency jobs faster than they could be done elsewhere and in most cases cheaper; and

(3) develop and test new procedures and equipment.

Today, the shops occupy three buildings on a seven-acre plot in north Tulsa adjacent to a railroad siding.

Arlie Zumwalt heads the 45-man work force. He reports to the maintenance superintendent, Tom Chilton.

Under Zumwalt is P. A. Howard, shop foreman, who has two assistants: Frank Keller in charge of the welding shop and George Burgess in charge of the machine shop. The blacksmith shop is under Howard.

Major repair job, making one block out of two cracked ones. Here a shops welder is cutting the cracked block down the middle with a cutting torch.

Newly designed equipment is turned out by the shops. The picture shows a rooter that Service Pipe Line Company is experimenting with.

Welders putting the finishing touches on a fabrication for field installation. At right pipe fabrications are being dispatched by truck to the field. Shops make manifold fabrications and scraper traps, strainers and pump piping, etc.

Buryel Fisher supervises the carpenter shop and reports directly to Zumwalt.

Dave Ramsey supervises the clerical force that writes up orders, keeps time, makes transfers, etc.

The shops maintain a warehouse primarily for the storage of sheet metal, bar steel, brass, etc., used in the shops.

Secret of the shops success is, of course, the personnel. Shops technicians, some of them with 33 years of service, have a total of several hundred years experience as machinists, welders, carpenters and blacksmiths.

Another factor is their equipment. The company provides the best lathes, planers, welding machines that enable the men to turn out anything from parts measured to a few thousandths of an inch to fabrications weighing tons.

For an example of how the shops function, let's take the crankshaft job:

Men in the mechanical section of the maintenance department drew up sketches of the job to be done and discussed them with Zumwalt. He located the materials needed, such as, the 1740-lb forging and notified the purchasing department where they might be bought.

He then turned the plans over to Shop Foreman Howard who assigned the jobs to the machines.

While one man machined off the jagged edge of the crankshaft and machined the forging, others were fashioning the necessary nuts, studs and bolts from the hardest steel available.

Handy Arrangement

Machines in the shops are so arranged that the men can move heavy pieces from lathe to drill to final assembly with an overhead hoist.

A truck and trailer backed through the large rear doors and the completed crankshaft was hoisted aboard with the overhead hoist. Shipping instructions had been furnished when the broken crankshaft arrived.

Clerks in the shops office figured the time and material spent on the job and charged it to the Missouri division.

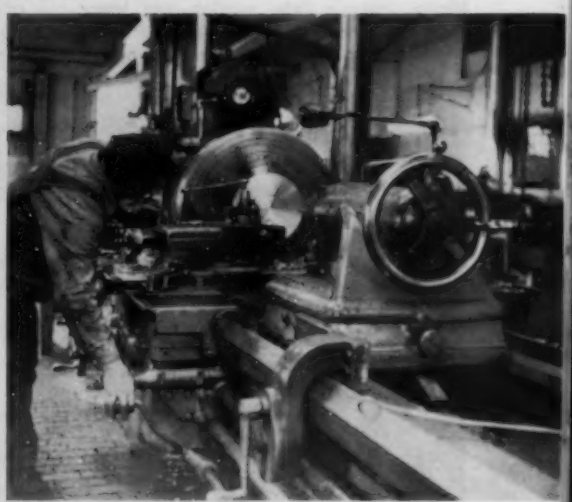
Welding Shop

Work done by the welding shop includes manifold fabrications and scraper traps, building of specially designed beds for heavy trucks and welding trucks, strainers and pump piping, instrument control panels and instrument housing.

The welding shop is equipped with

(1) a semi-automatic welding machine,
(2) 10 electric welding machines,
(3) a spot welder,
(4) a five-foot press break (for breaking steel),
(5) four-foot shear, and

Special projects sometimes include repairing crankshafts for pumps and engines. This crankshaft for a pump station in Missouri was repaired by Service Pipe Line's Tulsa shops at a cost one-fourth of what a new shaft would have cost. Secret of the shops success is skilled technicians working with the best equipment.



(6) four-foot bending roll (for shaping sheet steel into cone and cylindrical form).

Machine Shop

Work done by the machine shop includes repairs on all pumps and engines, manfacture of new bearings and shafts, and control instruments.

Connecting rods should also be included in the list. Service has experienced frequent breakage of connecting rods. The machinists are now turning out rods made from a better grade of steel than that furnished by the manufacturer, on the belief that the new rods will stand up better.

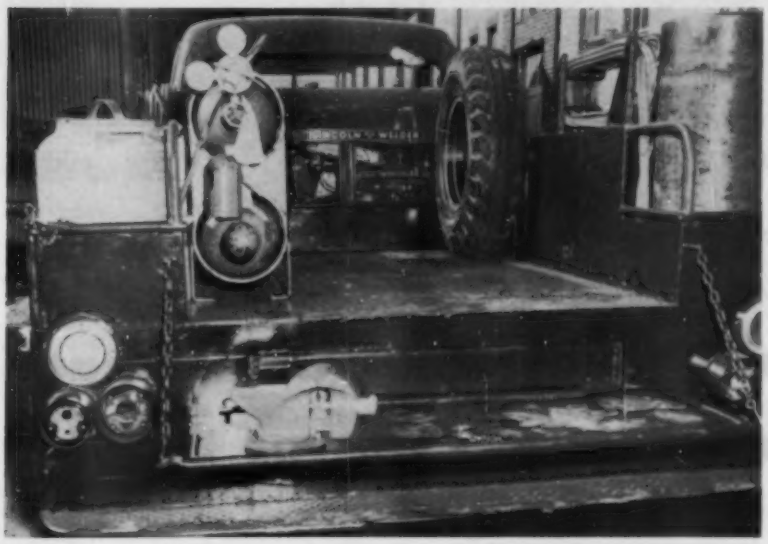
Equipment in the machine shop includes:

(1) seven lathes, sizes 13 (two each), 14, 16, 18, 24 and 32-in.,
(2) a number two and a number six milling machine
(3) 24-in. radial drill with a 6-foot arm and several small drills.
(4) two 6x24-in. grinders,
(5) a 300-ton hydraulic forcing press,
(6) 2 to 4-in. threading machine, and
(7) two power band saws.

The blacksmith shop re-babbitts bearings and works on gate valves among other things. Equipment includes a forging hammer, forge, and an automatic heat-treating furnace (for heat-treating small engine and pump parts, etc.)

Carpenter shop work includes refinishing furniture in the Tulsa office, making special items such as book shelves, and woodwork in the gauger's trucks built at the shops.

The carpenters have power tools of all kinds, including a table saw, band saw, joiner, drill press and sander.



Welding truck beds such as this one are completely fabricated by the welding shop, which also turns out special beds for heavy trucks and does the metal work on special gager trucks. Welding shop equipment includes 10 electric welding machines, a spot welder and a semi-automatic welding machine.

Interior of warehouse before shelves and equipment were added. Warehouse stocks materials such as bar steel, brass. Offices are through the door to the right.

Shops Also Conducts Tests

"Much of our time is spent experimenting and testing," Zumwalt says. On such projects the shops work closely with the engineers and maintenance department.

What experiments or tests the shops will make is usually decided upon by Maintenance Superintendent Chilton or Fay Cook, master mechanic, working with his assistant, Tom Llewellyn; or Art Hill, superintendent of line maintenance, and his assistant, Fred Zilm.

Recently, the shops conducted welding experiments at all temperatures on high-carbon pipe such as that used in Service's new large-diameter line from Ft. Laramie, Wyoming, to Freeman, Missouri.

When, and if, the time comes to make repairs on the line, the maintenance crews will know how to proceed, thanks to the experiments.

The shops manufactured company-designed scraper closure traps for the 24-in. section of the same Ft. Laramie-Freeman line. The company feels that the traps operate much easier than any that can be bought.

Safety devices are turned out for the safety section for testing as well as visual aids.

For example, they built a hydraulic chain tester. All load chains used in the shops and throughout the system are tested on the machine for safe working loads. The stress placed upon each chain is determined by its size.

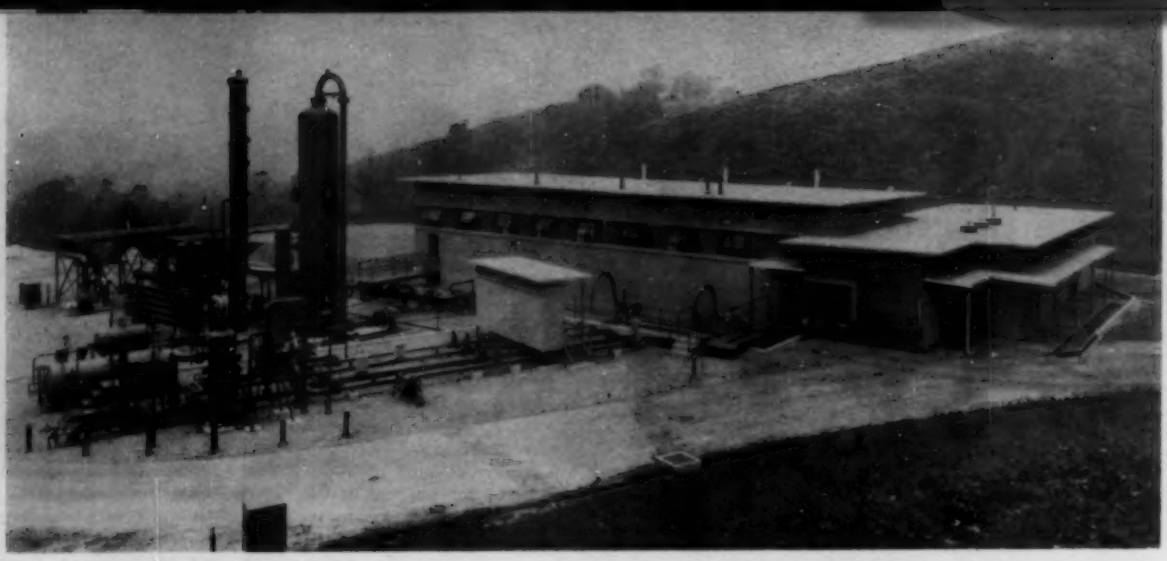
Visual aids for the safety section include a model truck "A" frame. The safety supervisor employs it to show work crews how to use the "A" frame correctly and safely.

Also included in the shops' special projects is a relief valve for older-type gate valves that will release internal pressure caused by external heating.

On such jobs the engineers or maintenance department designs the device, quite often consulting the shops personnel for their ideas. Blue prints are made, then during actual manufacture the shops and the engineers work closely together.

Upon completion of the device the shops subject it to the same conditions it will encounter while in operation. If any bugs in design come to light during these tests, the shops personnel and engineers iron them out together.

Through such close cooperation devices are developed that enable the pipe line to operate more efficiently. ★



General view — East Whittier, California, compressor station, Pacific Lighting Gas Supply Company.

P 625.6

Pacific Lighting Gas Supply found that consideration of adjoining residential property owners in developing plans and operations helpful as . . .

Suburban Underground Gas Storage In California Proves Feasible

RESIDENTIAL developments within the immediate vicinity of many depleted oil and gas fields have in the past eliminated consideration of these fields for storage operations as it was felt that such operations could not be carried on in the proximity of residential areas.

However, Raymond W. Todd, vice president and chief engineer, Pacific Lighting Gas Supply Company, told a Pacific Coast Gas Association group that approximately four years ago his company was successful in negotiating the purchase of a small oil and gas field located immediately adjacent to a residential area 20 miles east of Los Angeles, California.

This field was discovered in 1941 and produced substantial gas and oil over the next 10 years. By 1951 the gas was depleted and oil production had dropped below the economical limit.

Surface, storage and mineral rights were purchased for approximately 70 acres located on the near top of the reservoir zone.

Rights were also acquired to store gas in the reservoir underlying the surrounding 200 acres to be sure of controlling the entire reservoir.

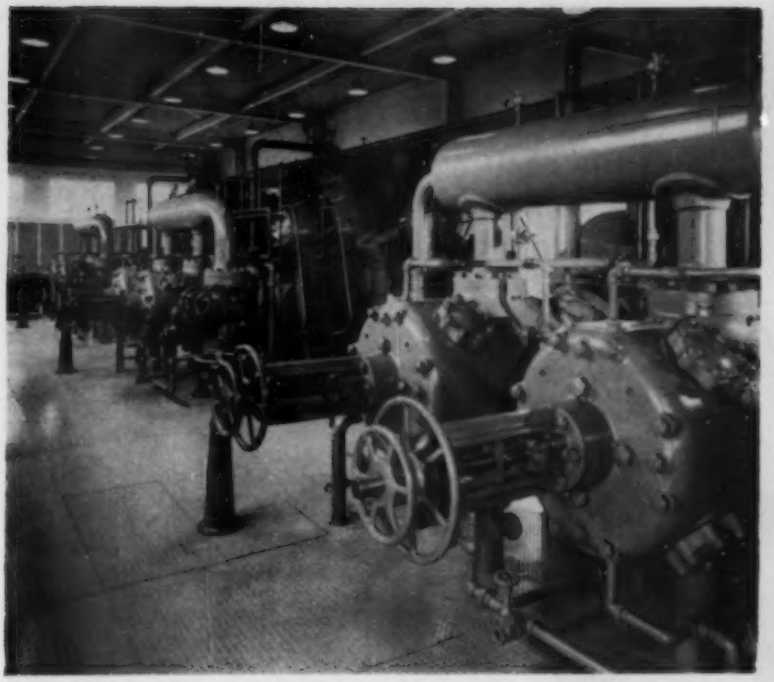
Pacific Lighting Gas Supply Company recognized that if the company expected to be able to operate such a field, it must conduct all developmental and subsequent operations in a manner that would not be objectionable to owners of surrounding residential property. The company immediately proceeded with a clean-up campaign, removing debris and junk. The area adjoined rolling hills with abundant brush and grass. Permission was obtained from the adjoining property owner to cut fire breaks across the hills, to protect the company's new property and the residential property.

Relations With Property Owners

Soon after the acquisition of the field, contact was made by the company with the local property owners association, and meetings were scheduled with the association's zoning committee to acquaint members with plans for the storage of natural gas. The meetings were held on the property so they could see the proposed location of the compressor station, the site being in as inconspicuous a place as possible, and to allow the company to outline its plans for landscaping the area surrounding the existing wells and station site area.

The approval of the property owners of the plans was not necessary, nor was it necessary for Pacific Lighting to obtain any zoning variance for its operations. However, the property owners association cooperated 100 per cent.

The property owners had developed a volunteer fire department, composed of residents in the immediate vicinity. A modest contribution to this organization not only assured Pacific Lighting of their cooperation, but also further



Interior view main compressor room containing three 440 horsepower compressor units.

evidenced the company's desire to become a part of the community.

Construction of compressor facilities and drilling injection and withdrawal wells would entail a large amount of heavy traffic on roads in the area that were normally carrying residential traffic. Inasmuch as there were several means of access to the storage field, a survey was made, and the company designated that access to and from the property should be by the route that would result in least traffic through the residential area. This route was posted so that persons traveling to or from the property could readily find their way without bothering the local residents for directions.

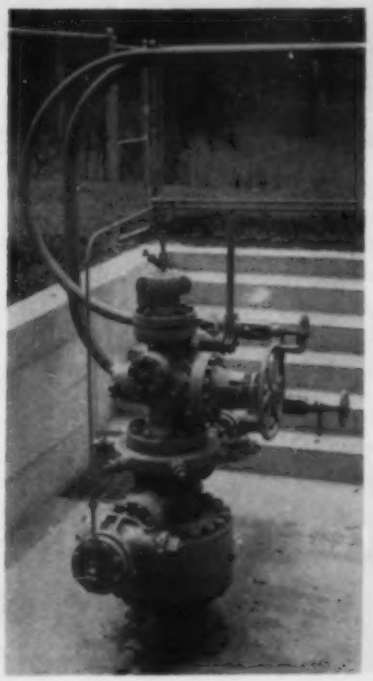
The heaviest traffic would occur in the early morning and late evening when residents were traveling to and from work. Therefore, Pacific Lighting specified in all construction contracts that no equipment, unless ordered in an emergency, could travel to or from the job site during these hours and that no heavy trucks or other noisy equipment could travel to the job site during night hours. All contractors have had to agree to comply with those restrictions. There has not been any complaint from contractors and none from property owners with regard to equipment traveling to and from the job.

Noise abatement

Several steps were taken to reduce the noise level to the lowest practical minimum.

First, all engines were equipped with

Christmas tree piping of Fullerton Well No. 6, East Whittier, California, compressor station.



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the best residential-type mufflers available.

Second, main compressor buildings and auxiliary buildings were constructed with concrete block walls and flat steel roofs, covered with built-up surface coated with coarse aggregate.

Third, blow-down stacks for emergency blow-down of the plant or blow-downs of pipe systems were also equipped with mufflers.

Fourth, trees were planted along the sides of the compressor station site that adjoined residential property.

An investigation of various types of soundproof buildings indicated that this type of construction had the best sound-absorbing characteristics within practical construction costs.

This tabulation gives some idea of the construction costs and sound-absorbing characteristics of the different styles of buildings considered:

Acoustic Quality and Cost of Building — Wall Types.
(100 to 120 decibel on interior)

Type of wall	Sound Transmission (Loss in Decibels)	Interior Noise (Reduction Coefficient)	Construction Cost Per Sq Ft of Wall Area
8-in. concrete block with filled cells	55.00	0	$1.10
Corrugated transite on steel frame with 2-in. Insulrock	20.00	0.80	$1.22
Rockwool batt in 3¼-in. "Q-panel" with 1¼-in. Acousti-Celotex on 1-in. x 3-in furring	61.60	0.75	$1.32
8-in. concrete (poured)	55.00	0	$1.33
2-in. steel studs staggered and laced with 1-in. rockwool between two ⅝-in. plaster panels	55.70	0	$1.45

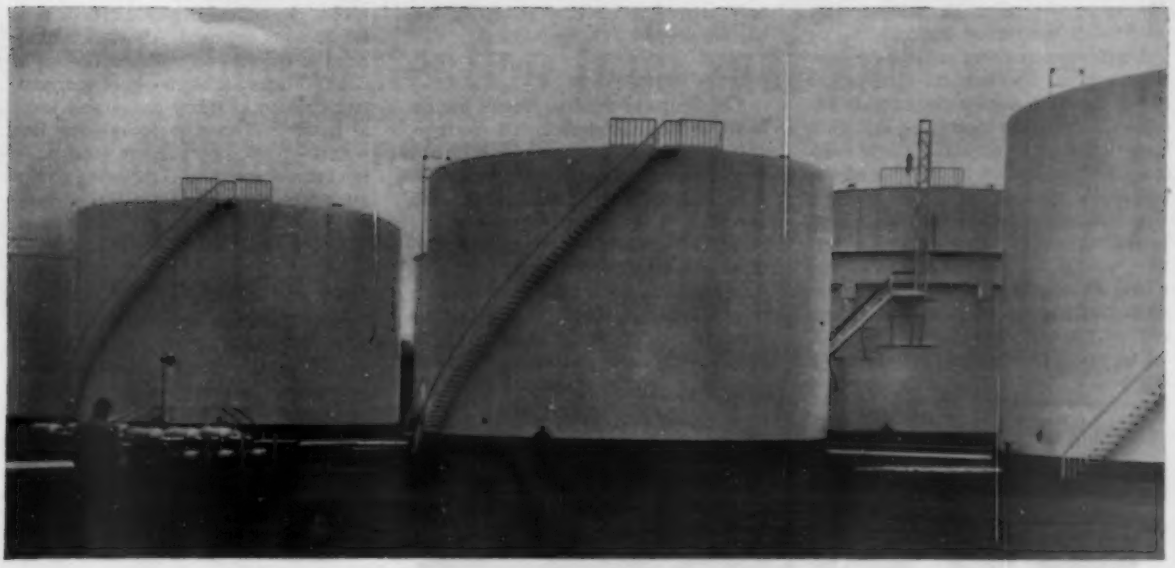
It was necessary also to give consideration to the noise problem in drilling additional injection and withdrawal wells. Here, the company followed generally accepted well drilling practices with the exception that the rigs were completely insulated with glass fibre mats that practically eliminated all noise.

Plant appearance

Plans for the main compressor building and auxiliary building were along modernistic lines. The flat, extended roof, the concrete block construction with horizontal mortar joint emphasized, along with a horizontal window pattern, all combined to give a low-appearing building, which blended with the extended covered passageways along the office part of the auxiliary building to give a very good appearance.

Facilities in the plant were located so that mufflers and air cleaners were away from residential development.

An industrial color consultant worked out a color scheme of light tans and shades of green for the building and all exterior piping. This color scheme has proved very acceptable.



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TWO NEW CALSO TERMINALS

An important step in the California Oil Company's expansion in the East was the recent completion of two 130,000-bbl terminals. They are located on the Buckeye pipeline, one at Vestal, N. Y. (near Binghamton), and the other at Dupont, Pa. (near Scranton).

Bethlehem designed, fabricated and erected the seven tanks at each terminal. Six are of 20,140-bbl capacity, 60 ft in diameter and 40 ft high—one of these being of lifter-roof design. The seventh tank at each plant is 10,000 bbl in capacity and measures 45 ft in diameter by 35½ ft in height. The Bethlehem liquid-seal lifter-roof tank that was installed at each of the two terminals effectively prevents breathing losses, not only of its own contents, but of that of two other tied-in tanks.

For full information about all types of oil storage tanks, propane tanks and gas holders, we suggest that you contact the Bethlehem sales office nearest you.

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The same general color scheme was used inside the station building.

Employees working around the new color scheme find that the elimination of aluminum paint on the outside facilities is easier on their eyes, and they state that working conditions have been materially improved by the use of the new color scheme.

Landscaping consultants set plants in the vicinity of the compressor station building and around each of the wells. Protective growth around the wells was suggested by the fire department to eliminate weeds and brush, which would produce a fire hazard. The use of ice plant in these areas has not only proved to be very attractive but has eliminated this fire hazard.

Design of facilities

The design of the compressor station facilities in general followed modern-day plant design. All facilities installed were designed in accordance with ASA B 31.1 code provisions and were sized to meet anticipated capacities. The first group of compressor units included three 440-hp Cooper-Bessemer GMV-4 units. This size unit was selected to meet fluctuating loads that might be incurred in injecting gas. Auxiliary facilities include generating facilities for plant and field use. Three high-speed, gas-engine driven 125-kva generator units are used. All service functions in connection with operations at East Whittier are electric-motor driven, to eliminate as many gas engine units as possible. This was desirable in line with the policy of keeping total noise level to a minimum. Generating equipment was considered essential, inasmuch as the field operations could be nullified by an outside power failure.

Field operation

Plant facilities were designed to operate at pressures up to 1200 psi, although to date the maximum wellhead pressure in the field has been 730 psi, or appoximately the original discovery pressure.

As the field is developed, it is anticipated that the maximum storage pressure will be increased gradually to approximately 900 psi.

Withdrawal gas is delivered at approximately 250 psi without compression.

Inasmuch as this field has been operated as a gas storage reservoir for approximately two years, a definite pattern of operating characteristics has not been established. However, the injection of gas and the resulting re-establishment of pressure in the storage zone has resulted in displacement of a certain amount of water. Proof of this comes from increased pressure in wells that were completed in the wet zone. These wells at the start of storage operations showed no pressure, whereas since the re-establishment of pressure in the zone, the wells have shown a definite build-up of several hundred pounds.

The ultimate working capacity of the reservoir cannot be definitely established. At present, there is an indication that the reservoir has a working capacity of 1.4 billion cu ft. To date, injection has an accumulative total of approximately 1.75 billion cu ft, while withdrawals total 1,145 billion cu ft. Withdrawal capacity is being stepped up to 50,000,000 cu ft per day.

In view of the strategic location of this field, it is anticipated that the reservoir will ultimately be operated in much the same manner as above-ground gas holders. The reservoir probably will not only be used to help equate annual loads but will also be used to equate daily and hourly load fluctuations.

As a result of the success of Pacific Lighting Gas Supply Company in being able to operate this field in a satisfactory manner and without serious objections from the surrounding property owners, Todd says the company is giving serious consideration to the development of gas storage in other fields that are close to residential areas. ★

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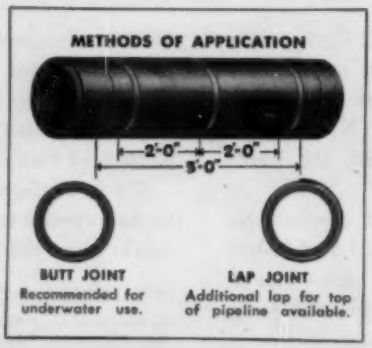

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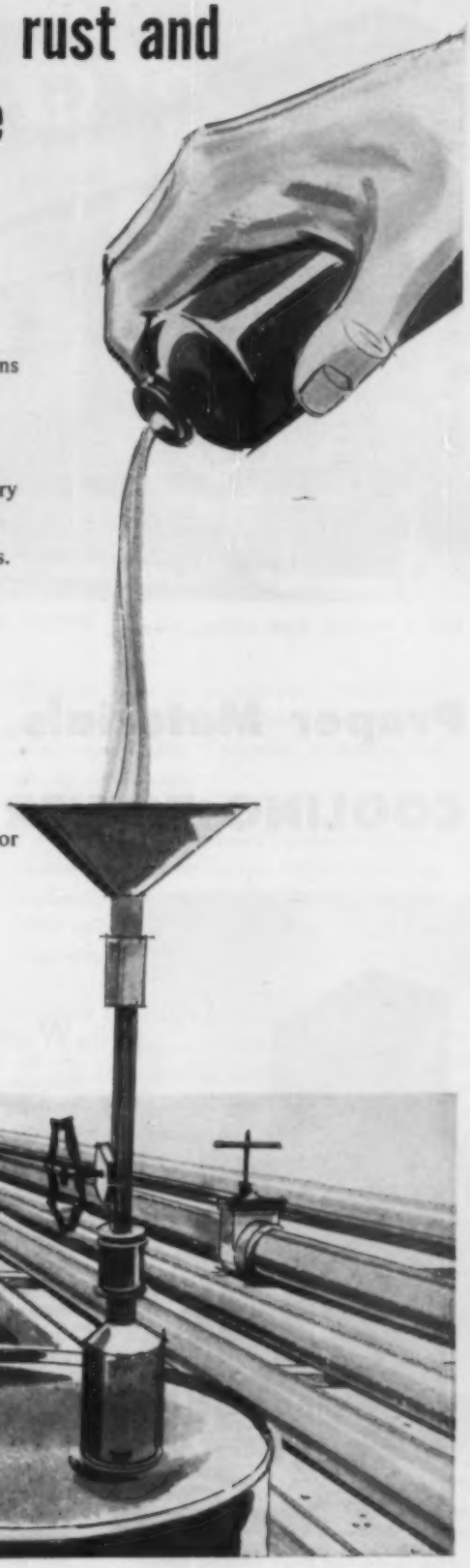

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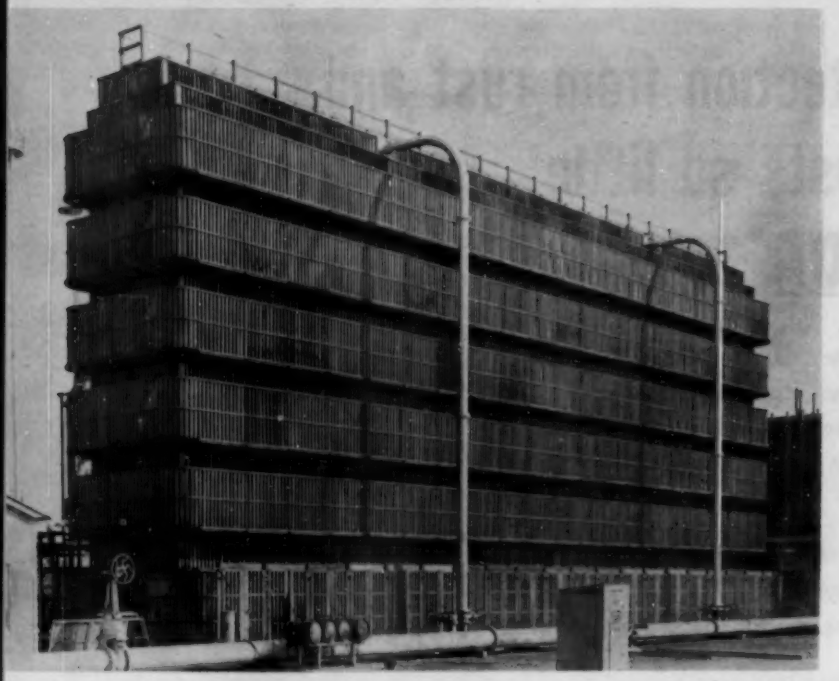

FIG. 1. Natural draft cooling tower.

Materials used in construction of cooling towers are of primary importance in preventing water erosion, chemical deterioration, and decay

Proper Materials Selection Can Prevent COOLING TOWER CORROSION PROBLEMS

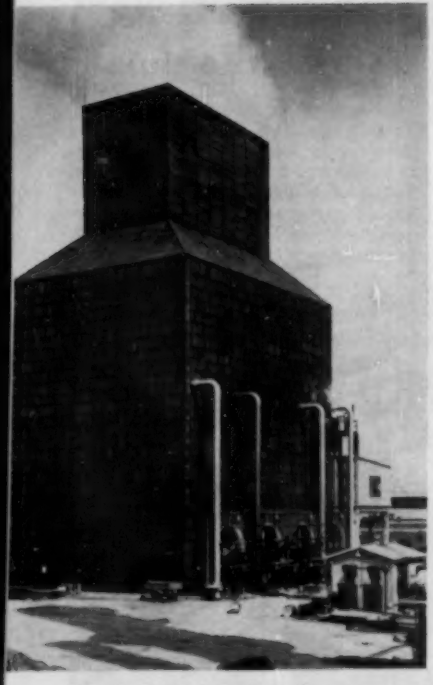

FIG. 2. Forced draft cooling tower.

F. C. Riesenfeld and C. L. Blohm
The Fluor Corporation, Ltd.

WATER occupies a very high place on the list of our critical natural resources. With the shifting of major industries from the traditional industrial centers along the Atlantic Coast and the Middle West to locations in the central and western portions of the United States, it has become increasingly difficult for larger industries to find adequate water supplies for their demands.

Water is needed in practically every industrial operation. One very effective means to conserve water is the utilization of recirculating systems, which are so designed that water used in cooling or condensing service is recooled and then recirculated to the processing operation. Among the several water cooling devices used in industry, the water cooling tower is the most prominent.

Basically, there are two types of cooling towers, distinguished by the use of either natural or mechanical draft for movement of the air. The natural draft, or atmospheric, cooling tower (Fig. 1) has been used in this country for many years. In foreign countries, this type of cooling tower is still predominant over the mechanical draft type, primarily because of the much higher fuel and power cost there than in the United States.

During the last 20 years, American industry has rather rapidly shifted toward the mechanical draft tower because it permitted more efficient operation both with respect to loading and obtainable cooling. The mechanical draft cooling towers are subdivided into two types, forced draft and induced draft. As is implied by the terminology, in a forced draft tower, as shown in Fig. 2, the air is blown upwards by a fan located in the lower portion of the tower, whereas in the induced draft cooling tower the fan is placed in the top section and the air-

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entering the bottom portion is drawn upwards through the tower. Fig. 3 shows an induced draft cooling tower.

Both the forced and induced draft cooling towers operate essentially on the countercurrent or, as it is also known, "counterflow" principle. Some designs employ "crossflow" operation, which is characterized by the fact that the air flows horizontally through the packed section. The construction of a crossflow cooling tower differs from that of a counterflow tower primarily in the arrangement of the louvers and drift eliminators.

Description of Cooling Tower

Fig. 4 shows a cutaway view of a typical draft redwood cooling tower consisting of two individual cells. Each cell of this unit is 24 ft long, 24 ft wide, and 30 ft high. In order to appreciate the function and the various material problems involved in cooling towers, a brief description of the different tower components will follow.

Normally, an industrial cooling tower rests on a concrete basin, which serves as a water surge capacity. In some installations this basin can be made of wood or metal. The entire tower is enclosed by a wall, in this case consisting of a double sheathing. The inner wall is composed of 1-in. thick redwood slats and the outer wall consists of a batten type redwood construction.

The louvers through which the air enters the tower are made of ½-in. by 6-in. by 3-ft redwood slats. The structural framing consists of 4-in. by 4-in. redwood members interconnected by internal gusset plates.

The packing, which is the heart of the cooling tower because it is here that the water contacts the air stream and is cooled by evaporation, consists of redwood decks of the sloping grid type. Other packings such as film type packings are also available, depending on the service of the tower.

Directly above the packing is located the water distribution system. Above the distributing system, drift eliminators are installed to remove entrained water droplets from the air stream. The drift eliminator shown in this picture is of the two-pass type and consists of ½-in. redwood slats.

The top decking, which is also made of redwood, is supported by a joist consisting of 2-in. by 6-in. members resting on 2-in. by 8-in. members. The fan assembly consists of a redwood fan stack and the fan itself.

Cooling tower fan blades are being manufactured from a variety of materials, such as type 302 stainless steel, carbon steel, aluminum, wood, and plastics.

Considering the operation of a water cooling tower, it is apparent that deterioration and corrosion problems of a different nature will be encountered in different sections of the tower. For example, the packing, which is always totally wetted by water, operates at a different condition than certain portions of the wall where alternate drying and wetting and concentration of solids may occur.

During the past years, a considerable amount of investigational work has been done in order to determine the most suitable and most economic materials for the construction of cooling towers. The selection of materials in a cooling tower depends not only on the conditions existing in the tower itself, but also on the fact that the water processed in the tower contacts metal surfaces in coolers and condensers, which have to be protected against corrosion and scaling.

In many cases it may be necessary to apply water treatment, which is not ideal for the protection of cooling tower materials, in order to protect metallic surfaces. The evolution of water treating methods that are satisfactory for both the cooling tower and metal surfaces in processing units is being pursued quite actively by many water treating companies, and a great deal of progress has been made in that direction during the past years.

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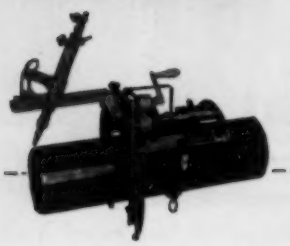

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FIG. 3. Induced draft cooling tower.

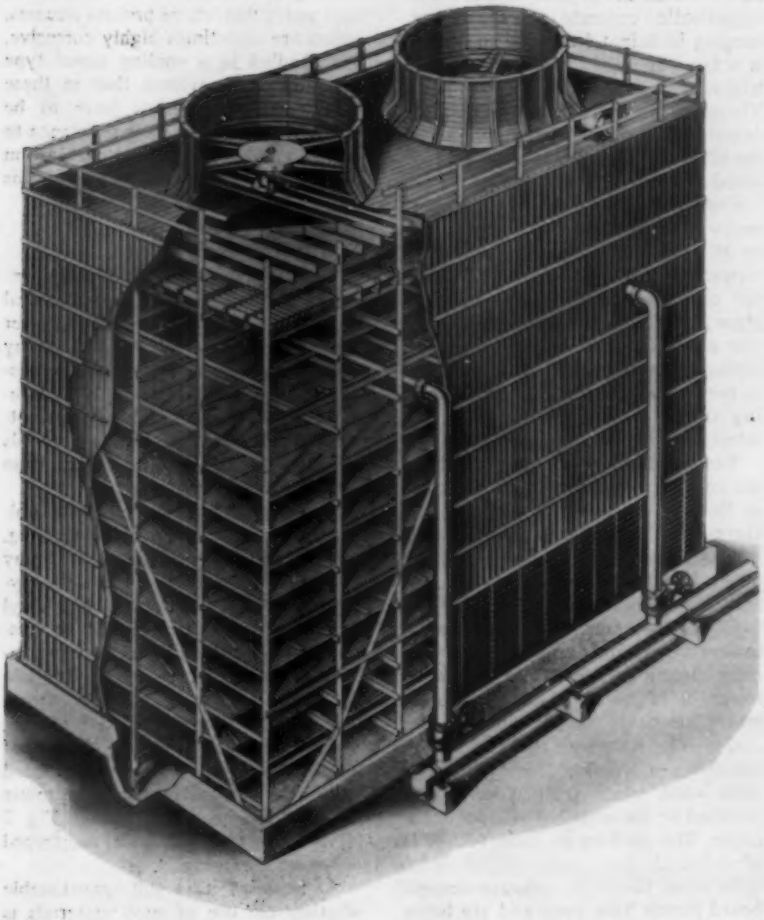


FIG. 4. Cutaway view of an induced draft cooling tower.

This paper is concerned primarily with materials that have been and are being used in the manufacture of cooling towers; therefore, the discussion of water treating practices will be limited to effects on cooling tower materials.

Metal Cooling Towers

Probably the earliest metal cooling towers were those used in ice plants and in small air conditioning systems. These units were constructed entirely of galvanized steel sheet and normally did not contain any packing, although in some cases galvanized sheet or redwood packing was used. Although these towers were quite useful and resistant to corrosion if used with relatively good water, they are at present being replaced largely with small wooden towers.

Because of its corrosion resistance to many different environments and its light weight, aluminum has been investigated for its possible use as a material of construction in cooling towers. This work has been done mainly by the Aluminum Company of America in its own research laboratories and in cooperation with some cooling tower manufacturers.

In order to overcome difficulties that were encountered in the early days in the application of aluminum in water cooling service, several alloys were developed and a great deal of knowledge has been gained in the proper water treating practices for optimum performance of aluminum. At present, it is thought that satisfactory aluminum sheet is available for use in cooling towers provided proper care is taken in the construction and installation of these units. Although some water treatment will, in general, be advisable, there are records available where aluminum towers have operated satisfactorily in many years with untreated water.

The Aluminum Company of America has assembled the history of a relatively large number of small aluminum cooling towers that have been in operation in various services, and most of these records show good performance over long periods of time. Some difficulties have been reported with aluminum castings, especially those having copper as an alloying element.

As a result of studies extending over the last 20 years, Alcoa[1] recommends that Alclad 3004-0 or Alclad 3004-H32 be used for sheet and plate items. For structural shapes, bare alloy 6061-T6 is recommended, and for fan blades, either 6061-T6 or 6063-T6 wrought alloys or casting alloy 356-T6 appears to be satisfactory. The most suitable material for packing formed of sheet is Alclad 3003-H14 of a minimum thickness of 0.032 in. The following

materials are recommended for the hardware in a cooling tower:

Bolts: 2024-T4 with No. 205 Alumilite finish or 6061-T6.

Nails: 6061-T91.

Rivets: 6053-T61.

Screw machine parts: 6061-T6.

Castings: 43 or 356-T6.

Fig. 5 is a photograph of an aluminum cooling tower that has been in service for approximately 18 years. This tower consists of all aluminum construction with the exception of the packing, which is California redwood.

Corrosion engineers agree upon the desirability of eliminating dissimilar metals in the construction of aluminum cooling towers. Parts fabricated of copper and its alloys and other heavy metals, such as nickel and lead, should be avoided in an aluminum structure.

It will be inevitable that small amounts of heavy metals are dissolved in the recirculating water, and therefore an adequate water treating system is necessary to protect the aluminum against corrosion. Aluminum alloy equipment has been used successfully in systems where the water treatment utilizes chromates, silicates, phosphates, borates, nitrates and nitrites, or combinations of these chemicals. Aluminum equipment can also be used in systems where pH of the circulating water is controlled by addition of sodium hydroxide, sodium carbonate or sulfuric acid, provided pH is maintained within a reasonable range.

At present, it appears that two types of treatment are especially effective for the protection of aluminum in water recirculating systems encountered in industrial service. One treatment that is available from a commercial water treating company is of the polyphosphate type with pH controlled at approximately 6.5. The second treatment contains a mixture of orthophosphate, citrate, and mercaptobenzothiazole.

Because in practically all cooling towers it is necessary to control the growth of algae by addition of proper algaecides, the effect of these agents on aluminum has been studied. It was found that, with the exception of heavy metal compounds such as copper and mercury, commercial algaecides such as chlorine are not detrimental to aluminum.

Various other metals are used in cooling towers in special applications. Quite recently, monel blades were introduced for use in cooling tower fans. In some cases where air conditioning cooling towers were built on top of modern skyscrapers, the entire wall was constructed of stainless steel in order to blend with the architecture of the building. An installation of this kind is shown in Fig. 6.

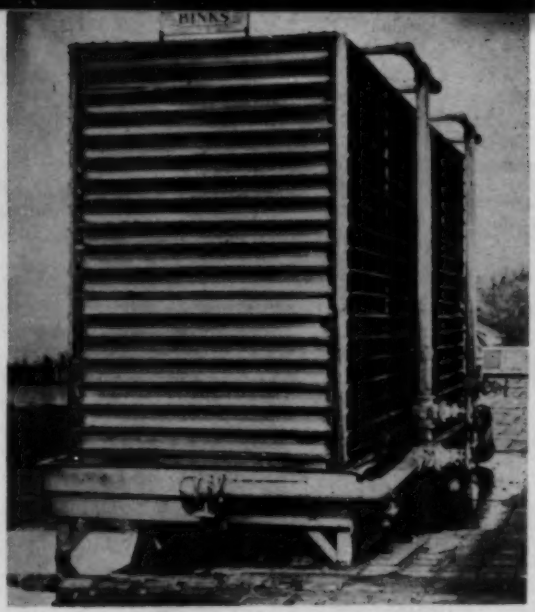


FIG. 5. Aluminum cooling tower — 18 years in service.

Concrete Towers

Most cooling towers in England and on the European Continent are of concrete construction. The primary reason for this is relatively high price of suitable wood in Europe and the desirability of high stacks in order to obtain a maximum of natural draft. The hyperbolic concrete cooling tower, ranging in height from 100 to 300 ft, is a familiar sight in European industrial centers, especially in power plants. These towers are constructed entirely from concrete with the exception of the fill in the bottom section, for which wood is used.

Concrete cooling towers are normally expected to last for a minimum of 30 years despite their susceptibility to some corrosive attack. It seems that the concrete is subject to attack by algae and, to some extent, by the chlorine used as algaecide, resulting in deliming of the cement. One method used to prevent or retard this attack is coating of the inside of the concrete structure with bitumastic.

Recently, concrete towers of different construction have been introduced in Europe, especially in England and Germany. These towers look very similar to the wooden cooling towers built in this country and consist of concrete frame and wall and wooden packing.

In this country, concrete cooling towers are used to a limited extent. The most practical application for such towers is in the air conditioning field where relatively small units are required. The American concrete towers consist of a wooden frame and concrete walls, which are performed and installed by the so-called "tilt up" technique. The packing in these towers is of redwood.

In some instances, asbestos cement board panels have been and are being used for the walls of cooling towers in conjunction with wood or metal frames and wood packings. The advantage of this material is its fire resistance. The asbestos cement sheet is subject to mechanical breakage and to deterioration by the circulating water, however.

There are special applications where cooling towers are used not only to cool water, but where process streams, which are sometimes highly corrosive, are handled in a cooling tower type structure. It is evident that in these cases, special materials have to be selected. Because of their resistance to corrosion, the use of ceramic or carbon rings in the packing of towers of this type has been proposed.

Plastic Towers

With the advent of relatively inexpensive plastic materials, it was natural that their application in cooling tower construction was investigated. Many plastics exhibit very good characteristics with regard to durability and resistance to chemical and biological attack. Furthermore, plastic materials are amenable to the type of fabrication involved in cooling towers.

The earliest use of plastics in cooling towers was confined to the piping, the distribution system, and the spray nozzles. Glass-fiber-reinforced polyesters, phenolics, butyrates, and vinyl type plastics are being used successfully in water distribution systems, including the spray nozzles. Reinforced polyester type resins are also being used in the construction of cooling tower walls. Quite recently, the use of plastics such as glass-fiber-reinforced polyesters and polystyrene[2] in tower packings has been investigated. Fig. 7 is a cooling tower with reinforced polyester sheathing.

At present, it is still questionable whether the use of such materials is economically advantageous over the

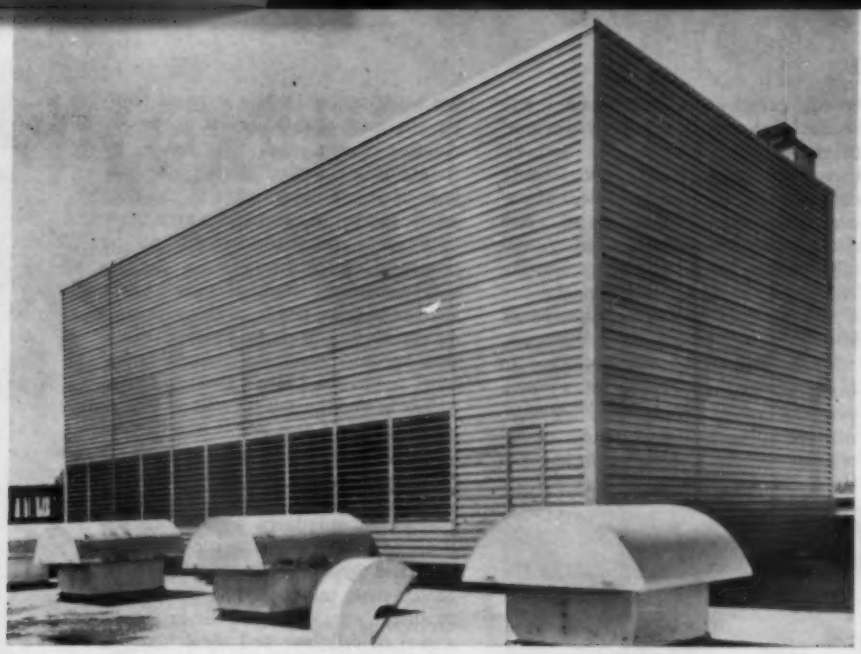


FIG. 6. Stainless steel cooling tower.

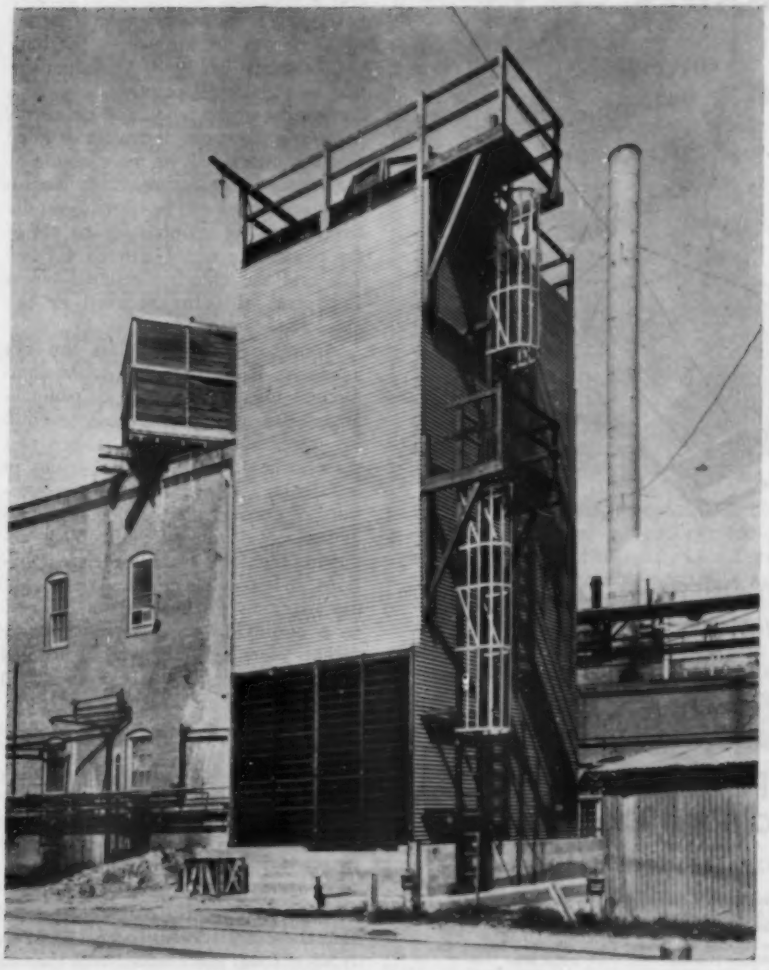


FIG. 7. Cooling tower with plastic wall.

commonly used redwood except under special corrosive conditions. In addition, there are very few service records available for plastic materials over extended periods of time, and it is therefore impossible to say with certainty how the life expectancy of plastics will compare with that of wood and other materials.

One difficulty inherent in some plastics that should not be overlooked is their susceptibility to degradation under the influence of light, principally ultraviolet. It appears, however, that small cooling towers, such as are used in air conditioning service, built entirely from plastic materials may be economically attractive. Rapid developments in the plastics industry and the continually changing price picture make it extremely difficult to evaluate the merits of plastics application in cooling tower construction. It is quite clear, however, that the elimination of the biological attack to which wood is subjected would make plastic materials extremely desirable in this application.

Wooden Towers

By far the most commonly used material in cooling tower construction is wood. In the United States, most cooling towers are constructed from California redwood, although Canadian red cedar, cypress, Douglas fir, and Southern yellow pine are used successfully. Among the soft woods, California redwood and Canadian red cedar are outstanding with respect to their decay resistance, dimensional stability, and workability. Cypress, which has desirable characteristics, is not being used extensively because only small sizes of lumber are available, which confines its utility to small installations. The use of Southern yellow pine, especially of long leaf yellow pine, seems to be increasing, although it appears that it is necessary to impregnate this type of wood with cresote or other wood preservatives in order to obtain a service life comparable to that of other species.

In Europe, the preferred wood is Canadian red cedar, although there is considerable use of Swedish redwood. The disadvantage of Swedish redwood, which is a pine, is the unavailability of clear grades, which limits its use to the packing. In France, Douglas fir and European larch are used to some extent.

Because of the increasing importance of cooling towers outside the United States, several Asiatic and South American wood species are being investigated for their possible utility in the construction of cooling towers. Among these, teakwood, mahogany and yakal from the Philippines, and certain Brazilian species appear to be quite promising.

Wood Deterioration

As wood is the most commonly used material in the construction of cooling towers, it is not surprising that it has been studied more extensively than any other of the materials mentioned. During the last five years, a considerable amount of experimental work was done in order to investigate the resistance of wood to conditions prevailing in recirculating water systems. The Cooling Tower Institute[3], the California Redwood Association[4], the U. S. Forest Products Laboratory,[5] The Institute of Paper Chemistry,[6] and various other organizations have conducted investigational programs along these lines. Several excellent articles describing the results of these projects have appeared in the literature,[7, 8, 9, 10, 11] and although the subject is far from being completely clarified, a great deal of understanding of the processes of wood deterioration has been gained. A detailed discussion of wood deterioration is beyond the scope of this paper, but a summary of the present status of knowledge will be presented.

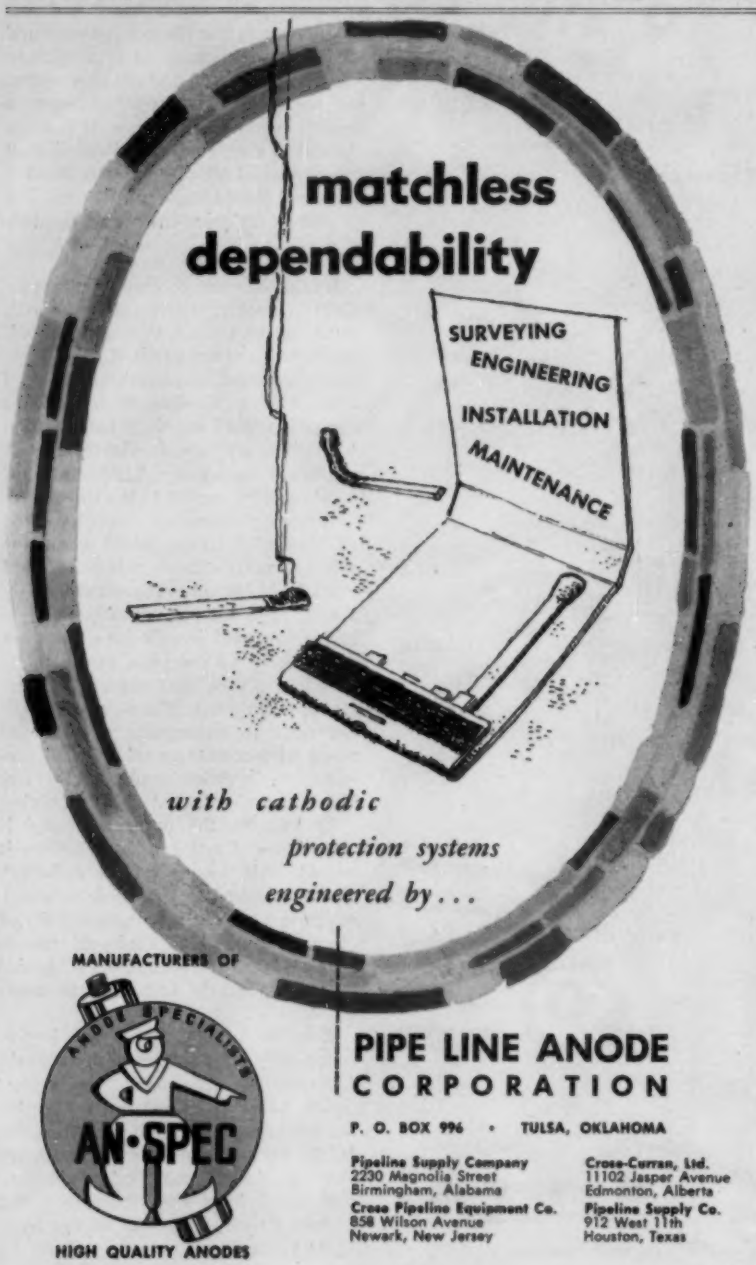
Cooling tower lumber is subject to three types of deterioration: (1) Erosion due to the continuous impingement of falling water; (2) chemical deterioration, which includes preferential leaching of certain components from the wood and reactions of wood components with agents present in the circulating water, and (3) attack by fungi, usually called decay. The first type of attack is negligible in its effect on the lumber as compared to the other two types, and therefore will not be discussed any further.

The chemical attack of cooling tower lumber is comparable to the processes occurring during paper pulping. Alkaline agents, especially sodium carbonate, remove the lignin (which acts as a cement for the cellulose fibers) from the wood, and as a result of this type of deterioration, cellulose fibers are exposed and eventually washed away by the water. This effect is greatly increased by relatively high concentrations of strong oxidants such as chlorine and bromine. It was found recently that, under certain conditions, chemical attack may result in the removal of cellulose and some hemicellulose, in addition to lignin, from the lumber.

Chemical deterioration of lumber has been recognized for a long time and is normally referred to as delignification. It is easy to diagnose from the white fibrous appearance of the lumber, as shown in Fig. 8. As delignification is a chemical reaction between a constituent of the wood and chemicals present in the water, it can be assumed that the attack will be more severe as the water temperature is increased. Chemical attack can be controlled relatively easily by maintaining the pH of the circulating water between 6.5 and 7.5, and the chlorine residual below 1 ppm if chlorine is used as the algaecide.

Although conclusive data are not available, it appears that other commercial algaecides, such as pentachlorophenol, are not injurious to cooling tower lumber. It can be seen that the chemical attack will be serious in installations where general considerations of corrosion protection of metallic surfaces dictate water treatments involving high pH. Even in such installations, it is possible to alleviate chemical attack by changing from chlorine to a non-oxidizing algaecide. During recent years, a gradual shift toward water treatments with pH of about 7.0 is taking place and the problem of delignification is disappearing quite rapidly.

The biological attack of cooling tower lumber has been recently recognized, and only in the last five years have intensive studies been conducted to clarify this rather serious problem. In order to appreciate the complexity of this type of attack, it should be noted that there are several hundred known types of fungi and bacteria which could attack lumber under conditions exist-



ing in cooling towers. Although chemical attack removes primarily the lignin from the wood, biological agents normally attack the cellulose by using it as their only supply of carbon. Certain fungi, particularly those of the white rot type, are known to be capable of removing considerable lignin as well as cellulose. In most cases, however, it is possible to recognize the type of attack occurring by determining the lignin-to-cellulose ratio in a deteriorated piece of lumber.

Observation and mycological studies of deteriorated lumber removed from cooling towers show that there are two types of microbiological attack. The first type occurs in the interior of the board and is not readily detectable from the outside. The board appears to be intact on the surface but can be crushed easily, and upon examination the interior shows almost total destruction of the wood, as shown rather dramatically in Fig. 9. This type of decay is observed primarily in areas of the tower that are not totally immersed in water but where conditions of high moisture within a temperature range of approximately 85-105 F prevail. These portions are the drift eliminators and certain areas of the wall. At present, it is believed that the organisms responsible for this attack are fungi of the class of basidiomycetes, which includes the typical wood-destroying fungi causing "brown cubical" and "white rot."

The second type of fungal decay occurs on the surface of the lumber and can be diagnosed from the checkered appearance of the infected piece. Fig. 10 shows a typical case of surface fungus attack. This type of decay is most prevalent in the packing section of the tower, and recent studies[12] indicate that it can be attributed to fungi of the ascomycetes or fungi imperfecti type. These organisms are known to produce a decay that is termed "soft rot." Although at present there is strong evidence that the biological attack on the surface is of the soft rot type, the information is as yet incomplete, and, therefore it cannot be stated with certainty that other organisms are not involved.

There are indications that a certain interrelationship exists between chemical and biological attack on cooling tower lumber. It has been established with certainty that both types of attack can occur simultaneously and it appears that a certain amount of chemical attack may be the necessary precursor for biological deterioration.

On the basis of present knowledge, it is thought that fungus infection is a random phenomenon that so far has defied correlation with the history of the lumber used and the condition of the circulating water, with the exception of pH and chlorine residual. Of course, the gradual removal of the extractives from the wood, which impart a high decay resistance to such naturally decay-resistant species as redwood, has undoubtedly some effect on the susceptibility to fungus attack. The removal of extractives is accelerated by chemical attack attributable to the presence of alkaline agents in the water. It is fairly well established that there is no difference in susceptibility to fungal attack between towers of different make, design or service. It seems, however, that atmospheric towers are less subject to such attack than mechanical darft towers.

Control of biological attack of cooling tower lumber presents an extremely difficult problem. So far, no suitable fungicide has been developed and the only measure that seems to be of some value is control of pH in the vicinity of 7.0 and maintenance of low chlorine residuals. As these conditions are also beneficial in the prevention of delignification, some strength is given to the argument that chemical and biological attack are interrelated.

In order to control fungal attack and to extend the life of wooden cooling towers, studies have been initiated to investigate the effect of wood preserv-

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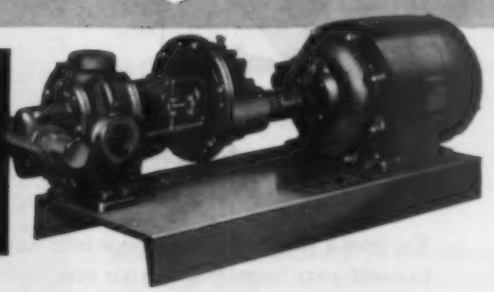

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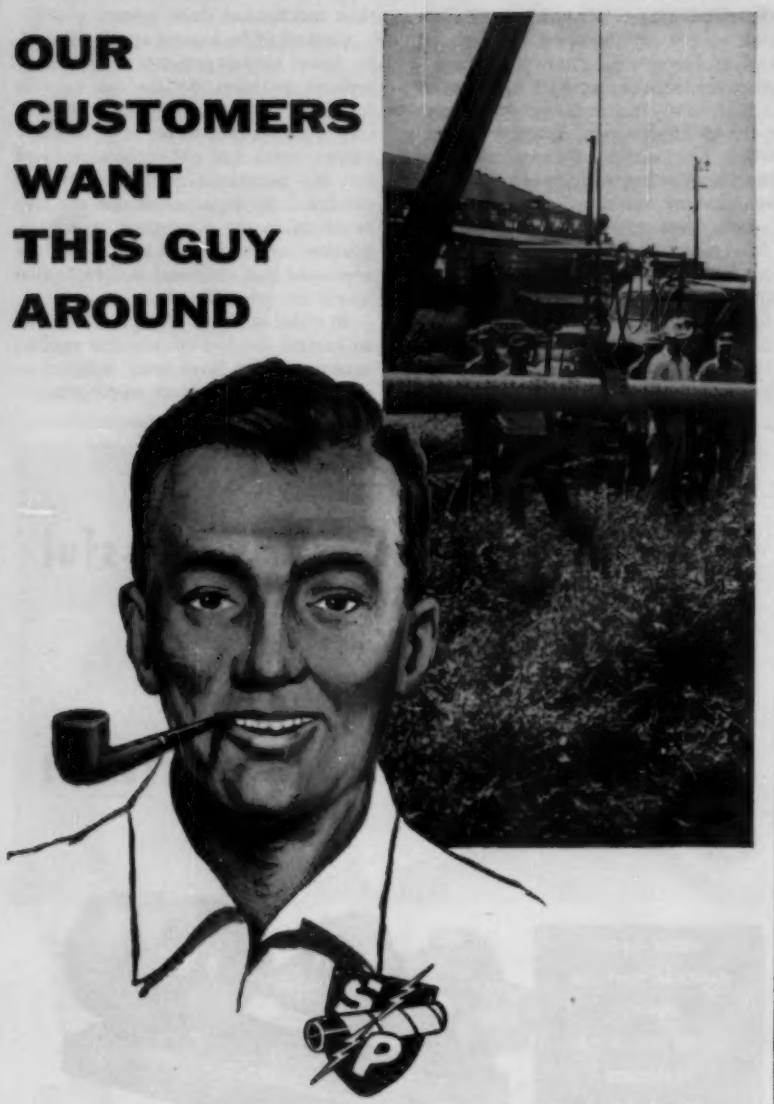

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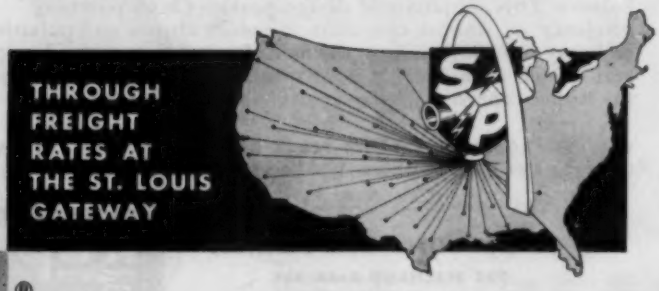

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atives. These studies have been conducted over a limited number of years and their results cannot be fully evaluated at this time; however, there are some indications that preservatives such as creosote,[13] and combinations of copper chromate and copper arsenate, are quite effective. It also appears that impregnation of wood with pentachlorophenol offers some protection.

Relatively long term service records[14] of creosote impregnated cooling towers indicate that pressure treatment to a retention of 8 lb per cu ft is very effective. Also, the work of British investigators has shown that lumber impregnated with chromated copper arsenate, also known as Green Salt or Erdalith, to a retention of 0.8 lb per cu ft will resist fungas attack very satisfactorily.

The U. S. Forest Products Laboratory has developed a rather original method for protecting wooden posts and other wood products against decay, which is know as the "double diffusion" method.[15] This method consists of first impregnating the wood with a solution of copper sulfate, followed by impregnation with a solution of sodium chromate. The insoluble copper chromate is precipitated on the wood fiber, which is then protected against the attack of the microorganisms. This method at present is being used for cooling towers and it is claimed that a retention of 0.3 lb per cu ft can be obtained by spray application. One advantage of this procedure is that cooling towers can be treated in place even after signs of biological deterioration have been observed. Because of the total lack of service records, it is too early to evaluate the merits of this procedure.

Hardware

In order to complete the story of materials used in cooling towers, a few remarks on materials used for the metal parts of wooden cooling towers are indicated. Under normal water conditions, galvanized steel or yellow brass are used for bolts and nuts. The anchor castings are made of cast-iron and the internal gusset plates consist of manganese bronze. Copper nails are generally used in the decks and the panels whereas silicon bronze nails are used in the fan stack. It should be pointed out that a variety of more expensive alloys, such as the stainless steels and monel, can be used in especially corrosive service.

In conclusion, it may be well to try to guess at future developments in cooling tower materials. The recent years have shown a considerable increase in the attention being paid to cooling towers by operators of large installations. The importance of cooling

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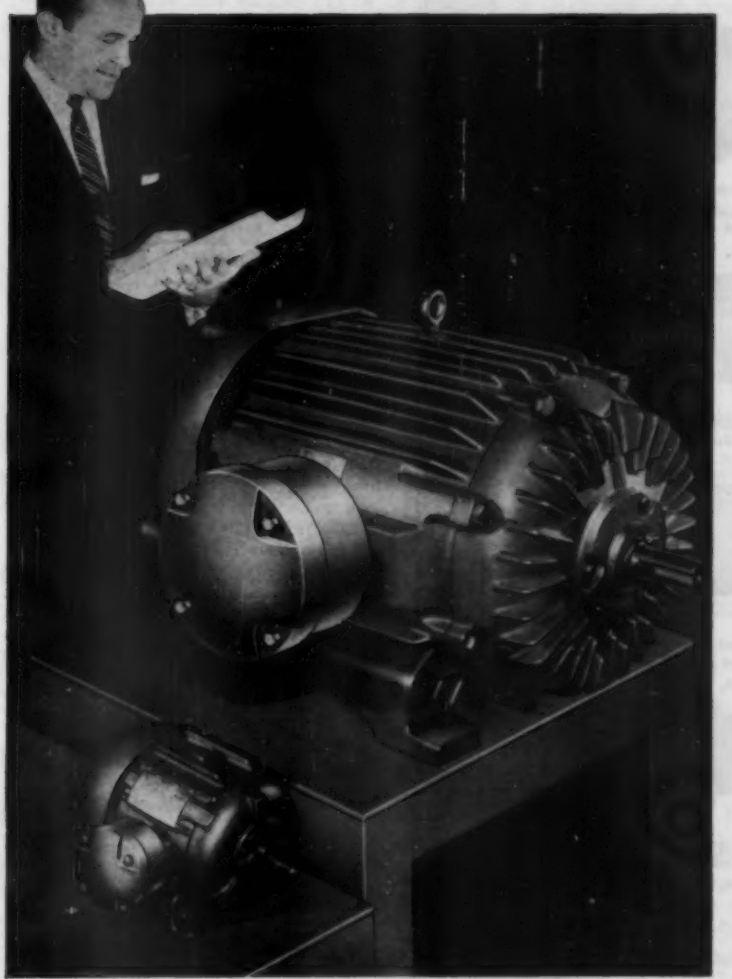

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towers will undoubtedly grow with the increasing water shortage in industrial areas, and economic studies will have to be conducted in order to evaluate the importance of factors such as first cost, maintenance, and replacement costs.

It appears to the writers that at present there is a trend toward impregnated wood and use of more expensive materials in cooling towers in order to extend the service life. It is quite probable that a more general application of plastic materials will evolve, especially if the problem of fungal attack of wooden towers increases.

As a closing statement, it can be said that the cooling tower has been recognized as being an important part of an industrial operation, which deserves the same attention of the operator as every other portion of his plant.

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Acknowledgment

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Pipe Line Projects

Trans Mountain Builds Station On Washington Spur

Trans Mountain Oil Pipe Line Company will construct a pump station at Laurel, Washington, on the company's spur line which serves the two refineries in the state. The station will be electric motor-driven and power will be supplied by the Puget Sound Power and Light Company system. Cost of the new installation will be $800,000.

Throughput of the Trans Mountain system now is 110,000 bbl per day, approximately evenly divided between the refineries in the Province of British Columbia and those in the state of Washington. The new station will be built with an eye to the future and to ensure that the spur line, which is 20-in. with 16-in. lateral lines to the refineries, will pump full main line deliveries when required from the main Trans Mountain 24-in. pipe line from Edmonton. It is planned that the station will incorporate a number of automatic and remote controls in order that its operation may be tied to the general control arrangements of the system.

Texas Gas Gets Permit For Additional Facilities

Texas Gas Transmission Corporation, of Owensboro, Kentucky, will construct new pipe line facilities to connect its transmission system with additional natural gas reserves in Louisiana. FPC permit for the construction was given recently.

Certificates also granted to three independent producers authorizing them to sell natural gas to Texas Gas. They are The Atlantic Refining Company, of Dallas, Texas, the California Company, of New Orleans, Louisiana, and Union Oil Company of California.

Texas Gas will build a supply line some 105 miles in length extending from a point in the East Lake Palourde Gas Feld, Assumption Parish, Louisiana, where gas will be purchased from the three producers, to Texas Gas' system near Eunice, Louisiana. Texas Gas also will construct loops paralleling sections of its existing system in Arkansas, Mississippi, Tennessee, Kentucky, and Indiana, and additional compressor facilities totaling 19,190 horsepower. Total estimated cost of the project is $19,969,000. The new facilities will be used to serve the increased firm requirements of Texas Gas' customers, estimated at 108,598,000 cu ft per day over its presently authorized service by the 1957-1958 winter.

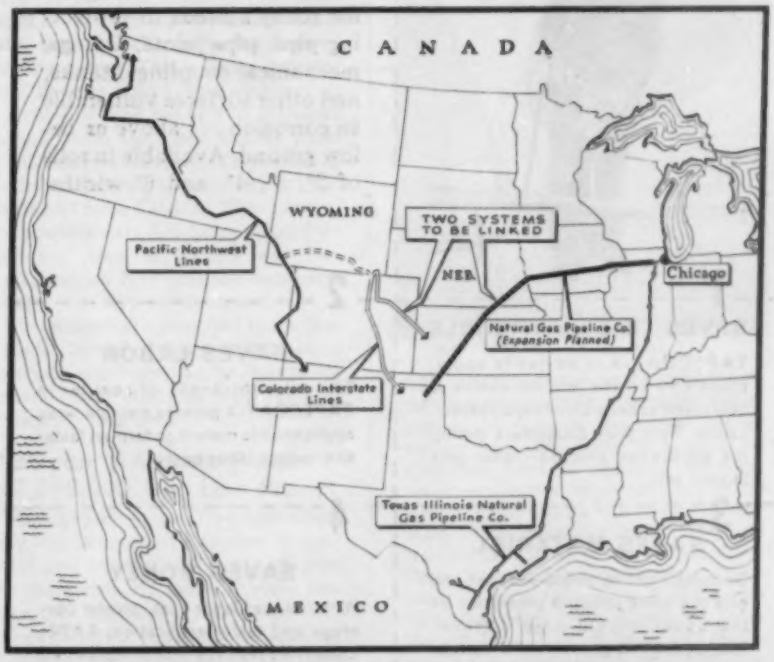
Natural Gas of America Line Gets FPC Examiner's Approval

Natural Gas Pipeline Company of America, Chicago, Illinois, has received a favorable decision by a FPC presiding examiner to construct a 350-mile pipe line to transport into its system natural gas which would be purchased in Jack, Wise and Parker counties, Texas, for ultimate delivery to markets in the Chicago, Illinois, area.

The decision, filed by Presiding Examiner Joseph Zwerdling, at the same time denied a competing application by Lone Star Gas Company, of Dallas, Texas, proposing to build a 230-mile pipe line in Oklahoma and Texas to make available natural gas to the Chicago line at a point near Fritch, Texas.

Three independent producers authorizing them to sell gas to Natural. He conditioned these certificates, however, by requiring the producers to file rate schedules providing for a base price of 11 cents per thousand cubic feet in lieu of the 15-cent price set forth in their contracts with Natural. The producers are Mid-Continent Petroleum Corporation and Warren Petroleum Corporation, both of Tulsa, Oklahoma, and Oil Drilling, Inc., et al, of Houston, Texas.

Natural's proposed 350-mile line would extend from Wise County, Texas, to a connection with its existing system at Fritch. The three producers would sell and deliver to Natural at the wellhead from various points in Jack, Wise and Parker counties an initial average volume of 78,000,000 cu ft of gas per day. Natural plans to obtain additional quantities of gas from points along the route of its new line, and has an ultimate objective of transporting a maximum of 240,000,000 cu ft per day through the new facilities into its system. Total estimated cost of proposed facilities is $28,487,000.



Major Expansion—Major linkage of Rocky Mountain natural gas sources with the Chicago area market for the first time is proposed in an application filed with the FPC by the Natural Gas Pipeline Company of America, a subsidiary of The Peoples Gas Light and Coke Company of Chicago. Connection would be with a new pipe line to be built by the Colorado Interstate Gas Company. Natural Gas Pipeline would expand its own line to bring 40 per cent more gas into the Peoples Gas system. The dotted double line shows an already approved pipe line connecting Colorado Interstate with the Pacific Northwest Pipeline Corporation. This line in turn makes connection with the major transmission line now being built from new Rocky Mountain gas fields by Pacific Northwest and connecting with lines being built from new fields in West Canada.

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Additional Louisiana Facilities Planned by Transcontinental

Transcontinental Gas Pipe Line Corporation, of Houston, plans to construct pipe line facilities to enable it to take an additional 38 million cubic feet of natural gas per day from the Live Oak gas field in Vermillion Parish, Louisiana.

The proposed new facilities, estimated to cost $707,000, include about 12.3 miles of pipe line and two meter stations. Transcontinental would purchase the additional gas from Sinclair Oil and Gas Company. The application says that the additional 38,000,000 cu ft per day would bring Transcontinental's total take from the Live Oak field up to 45,000,000 cu ft daily.

Westcoast to Lay Major River Crossings

Several major river crossings will be laid on the route of the natural gas pipe line being built by Westcoast Transmission Company Limited from the Peace River fields to Vancouver, B. C. Among the principal rivers are the Peace, the Parsnip, the Fraser, the Quesnel and the Thompson. The total number of major crossings will be about 13, with several minor crossings as well. At several points where the line crosses the right-of-way there will be an extra 10 ft of burial.

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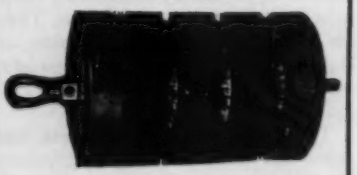

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Iroquois Gas Plans New York Underground Gas Storage Area

Iroquois Gas Corporation, of Buffalo, New York, has field an application with the FPC requesting authority for the construction of pipe line facilities in Chautauqua, Cattaraugus and Erie Counties, New York, to develop a new underground storage area for natural gas.

The project, which is designated the "Nashville Storage Area," will cost an estimated $2,877,200. The company would build about 14 miles of delivery pipe; 22 miles of gathering and well lines; drill 16 wells; and reclaim or recondition 64 existing wells. The project also would include a 900-hp compressor station.

Arapahoe Pipe Line Sets Expansion Program

The Arapahoe Pipe Line Company has announced plans for the expansion of its facilities.

The plans call for the acquisition by Arapahoe of several lines. These include approximately 33 miles of existing crude oil pipe line, 10 inches in diameter, running from the Adena Field in Morgan County, Colorado, northeast of Denver, to Merino, Colorado, together with gathering lines in the Adena area. This is being acquired from Pawnee Pipe Line Company.

A 42 mile pipe line of 8-in. diameter running from the Little Beaver Field in Washington County, Colorado, to Merino (a gatering system is included), purchased from Goodall Pipe Line.

Approximately 345 miles of oil field gathering lines in Kansas and Nebraska, which feed into the Arapahoe system, will also be purchased.

The Arapahoe's principal trunk line extends from oil fields in northeastern Colorado and Nebraska to Humboldt, Kansas, where crude oil is delivered to connecting pipe lines.

Michigan Wisconsin Plans $17,598,000 Gas Line Project

Michigan Wisconsin Pipe Line Company has announced intention to construct and operate 424 miles of pipe line extensions, 48 miles of main line loops, an additional compressor station of 6000 hp in Wisconsin, and the addition of 6600 hp at existing stations in Michigan and Wisconsin. FPC application has been made.

The new facilities would allow the company to sell natural gas to 10 distributing companies for distribution in 41 communities in Wisconsin and one town in Michigan. None of the municipalities to be served have now a natural gas supply.

Construction will be slated over a two-year period.

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Coastal Transmission Line To Take Texas Gas to Florida

Coastal Transmission Corporation, Houston, Texas, wholly owned subsidiary of Delhi-Taylor Oil Corporation of Dallas, has filed an FPC applivation to build a larger diameter natural gas pipe line from the Rio Grande Valley in Texas to a point near Baton Rouge, Louisiana.

Purpose of the line, estimated to cost near $60,000,000 is to deliver natural gas for ultimate consumption in Florida, company spokesmen state.

The line would connect some 20 gas fields in the Valley and will initially carry an average of 350,000,000 cu ft of gas daily. It would contain some 565 miles of 22 to 26-in. pipe and 272 miles of smaller diameter pipe.

The company's application stated that a 20-year agreement has been reached for sale of the gas to Houston Texas Gas & Oil Corporation. This firm has before the FPC an application for a permit to transport the gas to Florida.

Alberta Trunk Line Nearer To Gas Gathering Line Approval

Although start of construction will have to depend on progress of applications before the FPC for permission to import Canadian gas into the central northern states, the Alberta Gas Trunk Line Company Limited has cleared the last hurdle of official approval for the proposed route of its major gas grid gathering system in Alberta. Trunk Line is the exclusive operator to act as intermediate between producers, from which it will pick up gas, and Trans-Canada Pipe Lines Limited or any other company which may lay the main line eastward from the Alberta gate. Trans-Canada is stalled at present by the FPC requirements in respect of a hearing on the application by Tennessee Gas Transmission Company with which Trans-Canada has a contract for delivery of at least 200,000,000 cu ft of gas per day at the Manitoba-Minnesota border. This hearing may go far beyond 1956.

The trunk line proposal for a 100-mile shortening of its original route was approved in December by the Alberta Minister of Highways, pursuant to the recommendation of The Petroleum and Natural Gas Conservation Board. The new route starts at the Homeglen-Rimbey wet gas field, 90 miles southwest of Edmonton, and runs almost straight through to Cessford, the largest field in the east central area, picking up the Nevis field on the way and bypassing Calgary by some 120 miles.

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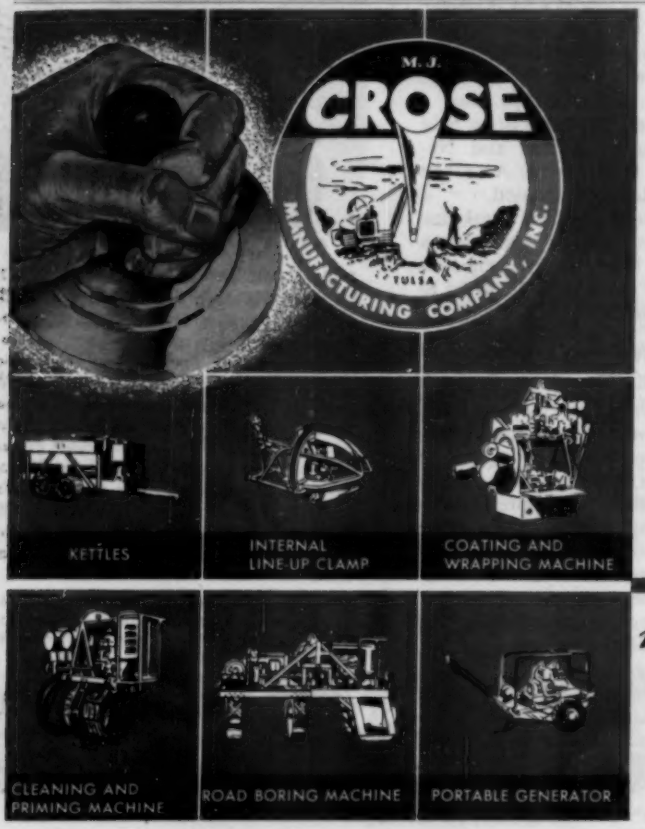

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Northern Plans Extension In Texas Panhandle

Northern Natural Gas Company, Omaha, plans to construct a gathering system and connecting pipe line in Hansford County, Texas. John Hanley, vice president, has announced that this system will be built to carry gas

into Northern's main line from wells in the North Hansford field.

Northern recently completed contracts with Baker and Taylor Drilling Company and Sharples Oil Corporation covering the purchase of gas from 16 Hansford County wells.

Northern will build a high pressure gas gathering system to the wellhead. Construction on the pipe line and a centrally located dehydrating plant is scheduled to begin this spring with the taking of gas scheduled to commence this summer.

Ultimately Northern plans to substantially enlarge its take of gas into its system from the Hansford County area. Northern sells gas in Kansas, Iowa, Nabraska, South Dakota and Minnesota.

New Construction Begins

Dutton-Williams Brothers, Ltd., Calgary, Alberta, has begun construction on 289 miles of new pipe line on three separate contracts.

The company began work January 14 on some 120 miles of 30-in. pipe for Westcoast Transmission Company. The construction is from Taylor, British Columbia, to Azouzetta Lake.

Dutton-Williams is laying 136 miles of 10-in. line from Lake Wabamum to Hinton, Alberta, for North Canadian Oils, Ltd. This work began January 11.

Also underway is 33 miles of 10-in. pipe for Western Industrial Gas, Ltd., between the Alexander Indian Reservation to Lake Wabamum.

Pasotex Pipe Line Plans Expansion of Facilities

Pasotex Pipe Line Company, Houston, Texas, is planning to increase its West Texas crude line from Wink to El Paso by some 45 per cent through the replacement of 76 miles of larger pipe to replace an existing system.

Pasotex, a subsidiary of Standard Oil Company of Texas, recently completed a project whereby 68 miles of the 195-mile Weink to El Paso line was enlarged to a 20-in. line, thus increasing carrying capacity from 45,000 to 55,000 bbl daily. This construction replaced two 8-in. paralleling lines.

Officials of the company say the line can be further expanded to an ultimate potential of 220,000 bbl daily.

T. S. Peterson, president of Standard of California (the parent company), pointed out that when Southern Pacific Pipe Lines, Inc. finishes the section of its new products pipe line from the Los Angeles Basin to Phoenix, Arizona, which is expected to be done late in February, there would be a pipe line system directly linking West Texas to Los Angeles.

"If there were an emergency," Petersen said, "products or crude oil could be transported all the way from West Texas to Los Angeles, with relatively simple changes in operation."

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NEWS

Service Pipe Line Completes West Texas Gathering Lines

Service Pipe Line Company has completed construction of eight miles of 2, 3 and 4-in. crude oil gathering lines to connect eighteen new leases in Lynn and Garza counties, Texas.

The new lines in the Company's West Texas division will be under the supervision of C. E. Wilson, division manager.

Oil gathered from the new leases will be injected into the company's main line system between Post and Monroe becoming a part of the company's more than 12,000 miles of pipe line.

Construction was contracted to the Horace Williamson Construction Company of Snyder, Texas. Work was started December 27.

Sinclair, Atlantic Gas To Be Sold to Transcontinental

Sinclair Oil & Gas Company and Atlantic Refining Company have won the approval of an FPC examiner to sell natural gas to Transcontinental Gas Pipe Line Corporation in Louisiana.

Examiner Glen R. Law gave the producers permission to deliver approximately 1,400,000 cu ft of gas daily during the first year with decreasing volumes being taken in successive years of a 20-year contract.

Transcontinental would build about 1600 ft of pipe line in the Palmetto field, St. Laundry Parish, Louisiana, at a cost of $17,500.

American Welding Society Holds Fourth Welding Show

The fourth Welding Show, sponsored by the American Welding Society, will be staged in the Memorial Auditorium, Buffalo, New York, May 9 to 11.

All available space for displays has been assigned. One hundred companies will conduct exhibits, and is expecting the largest show ever held in the industry.

Coincident with the show, the society will conduct its annual business meeting and a series of technical conferences. The metals engineering division of the American Society of Mechanical Engineers will, for the first time, join the American Welding Society in sponsorship of four sessions in which both groups have a mutual interest.

The welding committee of the Atomic Energy Commission also will co-sponsor a session.

Gas Delivery Termination Held Invalid by FPC

FPC has affirmed a decision by a presiding examiner holding that a group of 14 independent natural gas producers "have failed to show any cause" why they should not be required to obtain permission before terminating deliveries to Texas Illinois Natural Gas Pipeline Company, of Chicago, Illinois.

The proceedings were instituted in January of 1955 when producers were directed to show cause why they should not be determined to be natural-gas companies under the Natural Gas Act, and why they should not be required to comply with the provisions of that Act before abandoning any sales or service under contracts covering natural gas sales from the Clayton and La Gloria fields in Texas to Texas Illinois.

The contracts covering Texas Illinois' purchases in the two producing areas contain so-called "escape clauses," providing for termination at the election of the producers if the FPC imposed regulation upon them. The producers contended that the issuance of an FPC order in August, 1954, prescribing regulations to govern independent producers, constituted such regulation. The producers therefore served termination notices.

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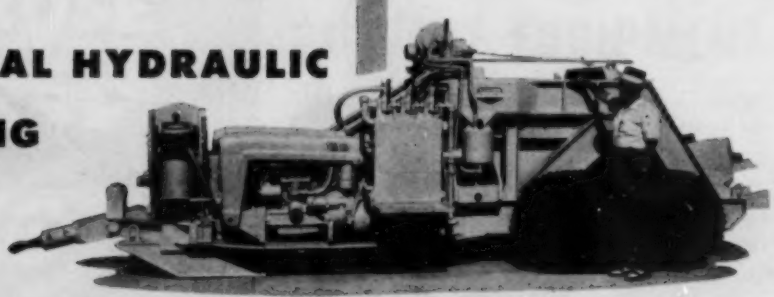

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Appalachian Corrosion Course Scheduled June 11-13

First annual meeting of the Appalachian Underground Corrosion Short Course is to be held on June 11, 12 and 13, Morgantown, West Virginia. It is sponsored by the School of Mines of West Virginia University.

On December 7, 1955, thirty-four representatives of major companies having underground structures met and organized the school to help fill the need for trained technicians in the field of corrosion control.

Purpose of the short course is to provide an opportunity for persons concerned with this subject to obtain information and acquaint themselves with corrosion mitigation.

Subjects tentatively on the program include corrosion prevention, corrosion testing, cathodic protection, coatings, design, and stray currents. The short course has received the acceptance of the American Gas Association and the endorsement of the National Association of Corrosion Engineers.

Iron Ranges FPC Hearings And Application Consolidated

An application by Iron Ranges Natural Gas Company, of St. Paul, Minn., and previously-scheduled hearings on proposals by Midwestern Gas Transmission Company and Tennessee Gas Transmission Company, both of Houston, Texas, involving the proposed import and export of natural gas from Canada, were consolidated by FPC.

Iron Ranges, which is proposing to construct natural gas pipe line facilities in Minnesota, would receive its natural gas supply from Midwestern's proposed project. The Iron Ranges project, estimated to cost approximately $4,000,000 initially, including several distribution systems, would have a system transmission capacity of 55,000,000 cu ft of gas per day. The company proposes to supply various towns and cities on the Mesabi Iron Range in Minnesota.

Skelly May Sell Gathering System in Low Gravity Field

Producers and the Kansas Conservation Commission are seeking a purchaser to take some 3000 bbl of low gravity crude from the Rhodes pool in southeastern Barber County, Kansas. Operators from seven companies were left with a market outlet on February 1 when Skelly Oil Company ceased its gathering in the area.

Skelly reports that the crude is undesirable because of the low gravity and high sulfur content. Indications are that the company is willing to sell its gathering system.

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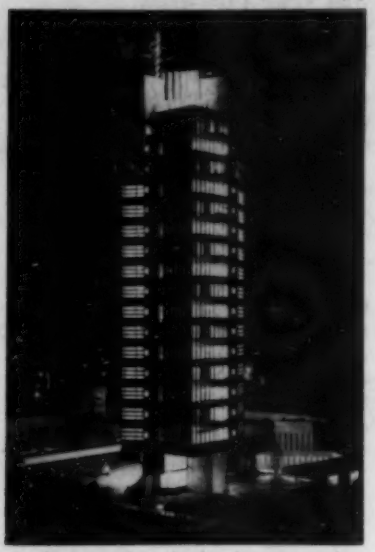
News

Price Tower Dedicated

The much discussed Price Tower in Bartlesville, Oklahoma, was dedicated in February. This 19-story building owned by H. C. Price Company, pipe line constructors, was designed by the world famous architect Frank Lloyd Wright, and has been acclaimed by many as among Wright's most important works. It is expected to have a strong impact on modern architectural design.



The Price Tower is of cantilever type construction with floors and walls suspended from four vertical steel-reinforced concrete supports. The Tower is narrow, having 45-ft wall faces. The building includes a two-story wing, which is occupied by the Bartlesville offices of the Public Service Company. Included in this wing is a small auditorium for display purposes.

Offices of the H. C. Price Company are in the twelfth through the nineteenth floors. Other portions of the building are available for office rental. There are also eight apartments in the Tower.

Arkansas Louisiana Considers Line Extension to Gulf Coast

Arkansas Louisiana Gas Company is considering construction of a $50,000,000 pipe line to the Gulf Coast within the next few years to bolster its natural gas reserves.

Although the line is still in the "probability stage," company officials say, it will likely be built in the next three years. Tentative plans indicate that the line would extend from a point near the Gulf Coast, either in Texas or Louisiana, to North Louisiana where it would be tied into the company's present system.

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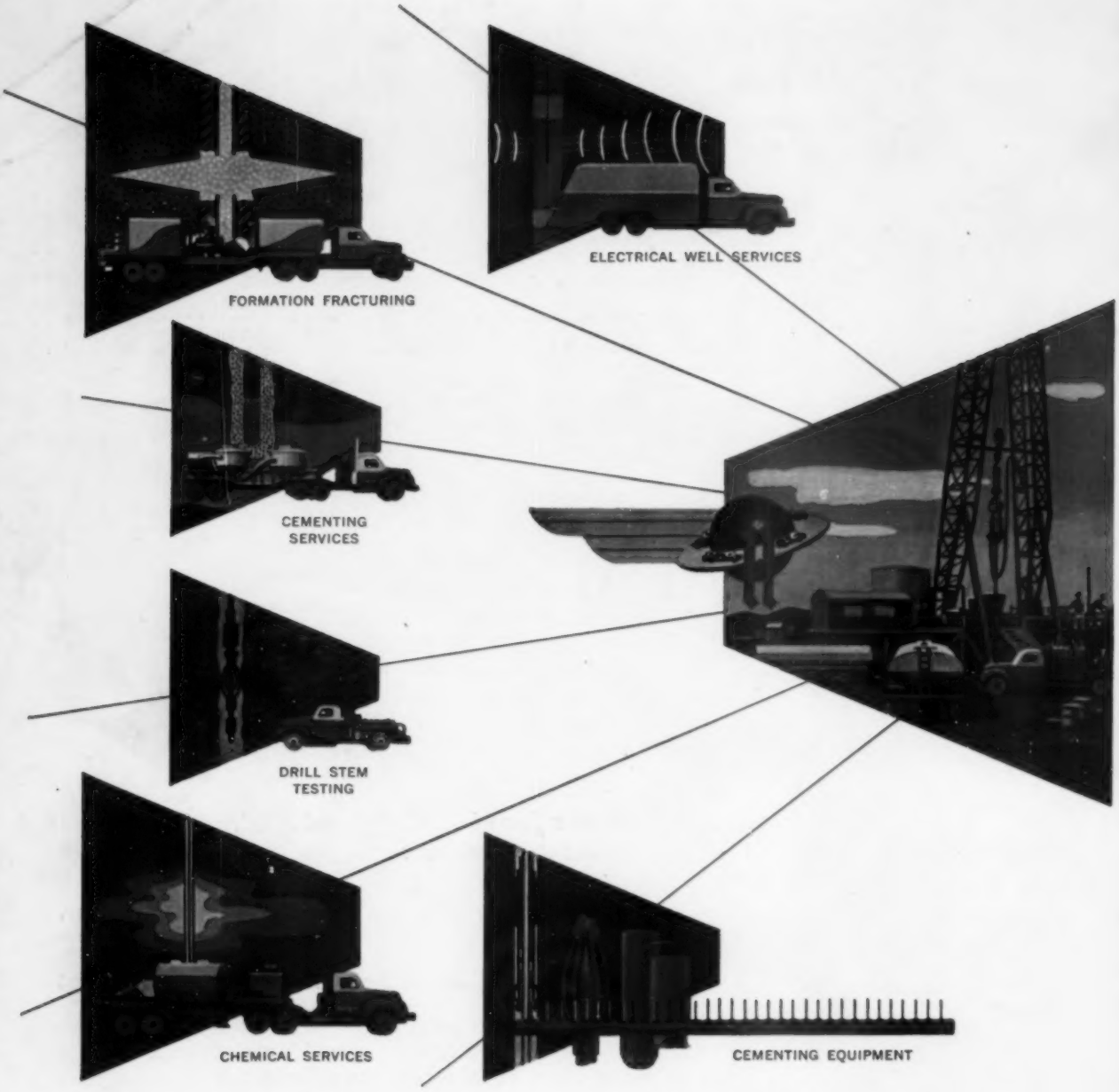

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